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THE

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THE WORKING OF STEAM ENGINES UNDER VARIABLE CONDITIONS.

THERE is very little doubt that in the ordinary everyday work of steam engineering, an excess of refinement is very apt to lead to the opposite results from those intended. This is especially the case in regard to the use of elaborate expansion gear, and the instances are numerous where direct loss has been brought about by undue elaboration. We have seen a plain slide valve engine altered by the addition of new valves with double back slide cut-off plates on the Meyer principle, and the only immediate results were the important one of more coal burned, and the unimportant one of much prettier indicator diagrams. The use of single valves, with direct coupled eccentrics actuated or varied by a fly-wheel governor, may be taken to represent a quite sufficient concession to elaboration of valve gear.

In another column will be found a short reference to a description of some tests by Prof. Weighton upon the experimental engines at the Durham College of Science. His conclusions are, of course, only absolutely applicable to the particular case of the engines he employed, but they may fairly be taken to be approximate for other engines. What he finds from the particular series of tests he has now been making is much as follows:—That the best point of cut-off in the cylinders of all multi-cylinder compounds, with the exception of the first cylinder, is an invariable, and depends solely on the capacity ratio of the cylinder in question and the one preceding it in the series. The point of cut-off thus determined is that which gives maximum economy.

This conclusion, it appears, holds good, whatever may be the point of cut-off in the first cylinder, and for any steam pressure that may be employed. This, if borne out by further tests, is a fact of great practical value, for it means simply that no variability need be applied to any cylinder except the first, but that the cut-off in all succeeding cylinders can be fixed by the engine designer, and no subsequent change can effect any economy. It is curious also that the point of cut-off in the later cylinders of triple and quadruple engines should coincide both for maximum economy and maximum power; but this does not hold good for the cylinder next following the high pressure cylinder in either engine. In the ordinary two-cylinder compounds, there is but slight difference between the cut-off points in the large cylinder for maximum power and maximum economy. Looking at this question from the standpoint of electrical traction or power distribution generally, with the wide variations in load which are found to be so inimical to economy, it would appear that the high pressure cylinders of such engines ought to be made fairly large in order that, by the rule given by Prof. Weighton, their low pressure cylinders may have a late cut-off. Thus a ratio of 3 : 1 would give, practically, a cut-off at one half the low pressure stroke, a result that has not been far missed as the

finding of general experience. A small cylinder ratio is certainly desirable for a compound engine on variable load for several reasons, even though it may make heavier demands on the strength of crank pins than more fashionable ratios call for. A large first cylinder enables a heavy and sudden accession of load to be more quickly picked up; at the same time that it opposes a greater back effect to the acceleration of an engine which is beginning to run away when suddenly relieved of load, and under the action of the steam still passing through the engine.

Prof. Weighton makes a further pointed remark to the effect that his tests show no marked evidence that the maximum economy of a steam engine is associated either with equal division of duty between the several cylinders, or with an equality in the several temperature ranges. Engineers who have been disposed to lay considerable stress on equal division of labour between the cylinders have, we are inclined to think, not had much foundation for their belief. We confess to having ourselves always been of the opinion that there was much more to be said on behalf of the equal temperature range theory, and even this may need to be abandoned. If it should prove that temperature range is of no importance, which we cannot at present think will be found to hold (as, logically, it should hold, to the extent of abolishing all compounding, so far as thermal savings are concerned), then are engineers thrown back upon almost purely mechanical reasons to explain the supposed economy of compound working? The surviving reasons would be chiefly that the leakage perimeters are less in the compound than in the simple engine, that there is less loss in the clearance spaces, and that the hotter cylinder is so much smaller and will lose less by radiation losses. May it not even be possible that modern accurately made engines do not leak steam past their pistons and valves, and therefore the sole reason now remaining for compound working is the great reduction of stresses on the crank pin, rods, &c., and the smaller high pressure valves required? We should like to see Prof. Weighton address himself to the subject of piston and valve leakage with a view to determining whether the leakage past a moving piston is greater than it is with the same piston when at rest. If this could be shown to be the case, it would go a long way to prove the mechanical argument for compounding.

Strikes in 1899.—The published statistics in the *Labour Gazette*, though not quite complete for the late year, are sufficiently so to disclose what we fully expected to hear, that the year was remarkable as having been freer of important disputes than any year of recent times. True, there was the jute trade dispute in Dundee, affecting 35,000 people, of some weeks' duration in August and September, but otherwise no dispute of the year affected as many as 10,000 people at once. There were in all 721 new disputes recorded, which affected 178,440 workers, and the duration of these was 2,496,358 working days. None of six preceding years has shown so good a record. The settlements effected were almost equally divided in favour of employers and of employés, or compromised. The worst strike was that of the plasterers, which affected 4,000 men, and had an aggregate duration of 200,000 days. Of the 178,440 people affected, London stands for only 6,876, and Ireland for only 2,878. Scotland was quarrelsome, and totalled up over 60,000, or over double as much as the 27,674 of happy and peaceful Lancashire, with Cheshire thrown in, the former county alone exceeding Scotland in population. There were 1,436 increases of wage, and only 17 decreases, exclusive of agriculture, the railways, and seamen. No fewer than 1,110,128 people had their wages raised. Only 1,069 were reduced. The workpeople in the employ of public authorities were chiefly those who enjoyed the benefit of shorter hours in which to draw the ratepayers' money. Observation of many public paid workers all down the scale seems to forbid the use of the word work. We note that at the adjourned general council meeting of the General Federation of Trades Unions held at the Queen's Hotel, Birmingham, there were present the representatives of 380,000 workers. There appears to be a tendency towards federation in both camps, and, probably, as with modern warfare, federation will enable both sides to fight so well that there will be more reason and less folly in future disagreements. The action of a paid agitator, as in 1897, could hardly receive the support of a federation of all industries. The new unionism is, we hope, dead, and has again made way for the more successful and better led unionism of the type of the Steam Engine Makers' Society, or Mr. Knight's Boilermakers' Society.

Société Internationale des Electriciens.—At the meeting of the Société des Electriciens an interesting paper by MM. Cuénod and Thury on the transmission of motive power to great distances by means of continuous current on the series system was read. The sitting took place on January 10th, with M. Violle in the chair. M. Cuénod first made some general observations on the system of series transmission. The question of economy must be specially considered. A transmission can only be economical if the cost price of 1 H.P. for a year does not exceed 100f. to 150f. The cost of installation should be about 1,000f. M. Cuénod referred briefly to the advantages and inconveniences of transmissions by continuous current in series and by alternating currents. He stated that M. Thury effected the first transmissions by continuous current in series in 1889 for an installation of 140 H.P. at 48 kilometres. At the end of 1889 M. Thury transmitted to various distances a total power of 16,300 H P. with generators each capable of giving a maximum of 3,600 volts. M. Cuénod showed that in this system the current remains constant, and only the difference of potential varies. It is found that the series system offers great advantages over the alternating current system. The efficiency of the dynamos is equal to that of the best alternators. There are no transformers and there is no induction in the lines. M. Cuénod estimates that a saving of 18 (?) to 20 per cent. can be realised. He also finds other advantages in the system, especially with motors. The working is simple and the maintenance easy. M. Thury then took up the subject and explained the various apparatus required in an installation of motive power for a series distribution by continuous currents. He made a table and described the following appliances: A short-circuiting apparatus, and an apparatus for avoiding sparks at the moment of starting. The maximum pressure used by M. Thury in his installations is 12,000 volts, but he hopes soon to arrive at 22,000 volts.

The Institution of Mechanical Engineers.—The annual report of the Council, presented at a recent meeting, contains, among many other statements, the following remarks *re* work now proceeding:—

Progress has been made during the year with the various researches undertaken by the Institution.

The fifth report of the Research Committee on Alloys was presented and fully discussed at the February meeting, and Sir William C. Roberts-Austen, the reporter, is now at work upon the effect of annealing and tempering on the properties of steel, which will form the principal subject of the next report.

The gas engine research has been further advanced by Prof. Burstall, who hopes to be able to present his report early in the present year to the committee under the chairmanship of Dr. Kennedy.

The value of the steam-jacket is the subject under investigation by Prof. Beare, who has accumulated further data towards his fourth report to the committee under the presidency of Mr. Henry Davey.

The compound steam-jacketed condensing engine at King's College, London, has been working. Prof. Capper has not yet been able to commence the first series of complete tests, but promises his first report soon.

RECENT PAPERS ON THE COMMUTATION OF THE DIRECT CURRENT DYNAMO.

Thorburn Reid.—"Sparking, its Cause and Effects": read at the meeting of the American Institute of Electrical Engineers, December 15th, 1897.

T. Fischer Hinnen.—"Observations of Methods of avoiding Sparking in Continuous Current Machines." *Elektrotechnische Zeitschrift*, December 30th, 1897.

Eustace Thomas.—"Sparking in Dynamos." The *Electrician*, February 18th, 1898.

H. N. Allen.—"Sparkless Reversal in Dynamos." *Journal of the Institution of Electrical Engineers*, April, 1888.

W. H. Everett and A. H. Peake.—"Experiments on Commutation in Dynamos and Motors." The *Electrician*, April 22nd, 1898.

W. H. Everett and A. H. Peake.—"The Effect of Commutation on the Field of Dynamos and Motors." The *Electrician*, December 30th, 1898.

E Arnold.— *Elektrotechnische Zeitschrift*

G. Kapp.— *Elecktrotechnische Zeitschrift*, 1899.

(*Continued from page* 87.)

As to a value to be assumed for f, the field error. F, the rate at which flux is to be withdrawn from the coil during the period 2 T to produce perfect commutation, is a nearly uniform rate which withdraws 200,000 lines in a period ·002 second. So that the value of F is nearly constant at 10^8 units. Suppose the commutation field to be in error by about 10 per cent, so that $f = 10^7$, and may be assumed constant for the values of x between -1 and $+1$, *i.e.*, during the whole commutation period we are considering. Inserting these values in the expressions for a, b, and g, we have—

$$a = 005$$
$$b = \cdot 1$$
$$g = 1,$$

and γ the excess current in the local circuit

$$= \epsilon^{-\cdot 005\, x} \left(\frac{1 - x}{1 + x}\right)^{\cdot 1} \int_{-1}^{x} \epsilon^{\cdot 005\, x} \left(\frac{1 + x}{1 - x}\right)^{\cdot 1} dx.$$

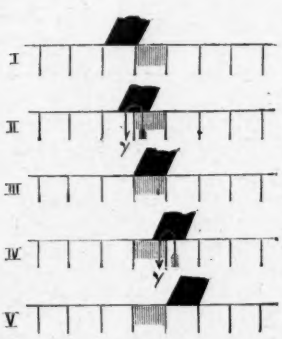


Fig. 12

The evaluation of this expression gives the values for γ in the series of positions between positions I. and III., fig. 12. In position I. $x = -1$ and $\gamma = o$. In position II. $x = o$ and γ is in the direction of the small arrow. In position III. $x = +1$, and $\gamma = o$.

The diagram of fig. 13 gives the results of the evaluation.

Curve A gives the value of $\epsilon^{\cdot 005\, x} \left(\frac{1 + x}{1 - x}\right)$.

Curve B gives the value of $\int_{-1}^{x} \epsilon^{\cdot 005} \left(\frac{1 + x}{1 - x}\right)^{\cdot 1} dx$ obtained by graphical measure.

Curve C gives the value of γ, which is the ratio of the ordinate of B to that of A.

Curve D gives the value of the electromotive force acting from the brush towards bar A (fig. 12) obtained from the formula—

$$e_1 = \frac{2\,r}{1 - x}\,\gamma.$$

Curve E gives the value of the electromotive force acting from bar B (fig. 12) towards the brush, obtained from the formula—

$$e_2 = \frac{2\,r}{1 + x}\,\gamma$$

The currents and electromotive forces given by these curves are due to the field error, and are to be added to or subtracted from those which are characteristic of perfect

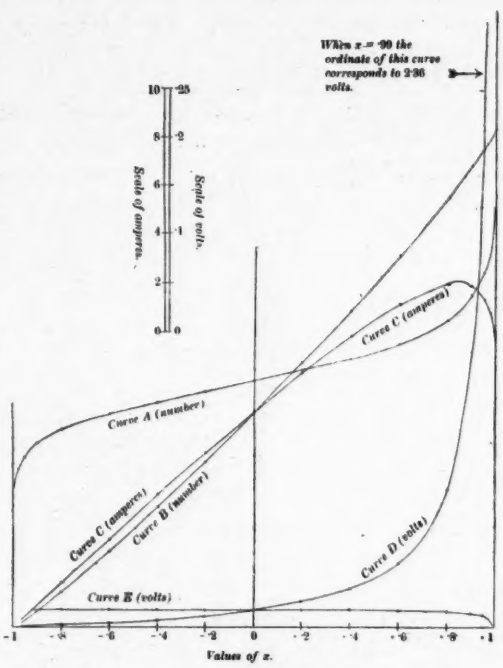

When x = ·99 the ordinate of this curve corresponds to 2·36 volts.
Scale of amperes.
Scale of volts.
Curve A (number)
Curve C (amperes)
Curve C (amperes)
Curve B (number)
Curve D (volts)
Curve E (volts)
Values of x.

Fig. 13.

commutation. In the case considered a current of 200 amperes is passing through a contact resistance of ·001 ohm, so if the current is evenly distributed the fall of potential over the whole surface is ·2 volt. The electromotive force given in curves D and E are to be added to or subtracted from this, according as the commutation field is in defect or excess.

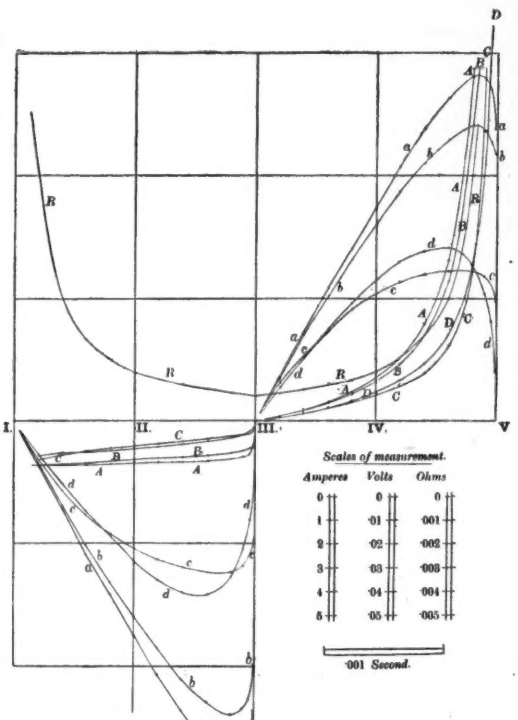
The forms of curves D and E show that only just before the commutator bar leaves the brush does the electromotive force due to the field error assume much importance. This force here does not exceed ·4 volt except for the last sixteenth part of the commutation period. If in the case we are considering the permanent difference of potential of ·2 volt were in an opposite sense to that due to the field error, this error would produce only an insignificant effect on the distribution until the bar was just about to leave the brush. When $x = \cdot 99$, *i.e.*, $\frac{1}{100000}$th of a second before contact is broken, a current of 12 amperes would be passing with a fall of potential of 2·2 volts. This is sufficient to produce a serious spark. The general conclusion that the action is confined to the time just before contact is broken corresponds with observation that sparking takes place at the toe of the brush.

It may be observed that the effects that have been tabulated are directly proportional to the magnitude of the field error, and the energy expended in the spark is proportional to the square of this error.

§ 16.—The sparking at the toe of the brush produced by error in the commutation field can be reduced by modifications in the arrangements of the commutator and brushes. Modes of doing this by inserting resistance either into the armature connections, or into the body of the brush, have already been referred to, and this section deals with the character of the improvement obtainable by such means. To show this we shall trace the values of two quantities during the commutation period, calculating their respective values at each instant, for several arrangements of brush collection. These two quantities are the fall of potential from the brush to a commutator bar, and the current passing from the brush into the commutator bar. So far as these quantities are due to an error in the commutation field, and their values will be traced during the whole time that a given bar is underneath

the brush. Fig. 12 shows a series of positions of a commutator bar (the one shaded) during this period, and the two quantities to be discussed are the difference of potential between the brush and the bar, a quantity we may call ϵ, caused by the field error and the current γ. In the first half of the period, *i.e.*, between the positions I. and III., the values of ϵ and γ are both negative, between the positions III. and V. they are both positive. The whole period I. to V. is twice the time that has been called the commutation period, and the series of values of γ in the first half is I. to III., is the same only with reversed sign to that of the second half III. to V. The figures along the axis of ordinates of fig. 14 show to which position of fig. 12 the several points along the curves refer.

In fig. 14, nine curves are plotted.



Values of ordinates 10^{-1} second before the contact is broken at V.

A 2·36 volts.
a 11·8 amperes.

B 1·99 volt.
b 9·9 amperes.

·99 volt.
C 4·95 amperes.

D ·41 volt.
d 2·05 amperes.

FIG 14

The curve R gives the resistance of the contact area between the brush and the commutator bar which is supposed to be the same in all cases, viz., ·025 ohm per sq. cm.

The curves marked A, B, C, D are curves of E.M.F. between brush and bar, values of ϵ.

The curves marked *a*, *b*, *c*, *d* are curves of current between brush and bar, values of γ.

The curves A, *a* refer the case when there are no armature connections and no extra brush resistance. In the analysis of § 14 $a = \cdot005$, $b = \cdot1$, $g = 1$.

The curves B, *b* refer to the case when armature connections are used, each of which has nearly 20 times the resistance of an armature section, ·00195 ohm. In this case for the analysis of § 14 $a = \cdot2$, $b = \cdot1$, $g = 1$.

The curves C, *c* refer to the case when the armature connections are nearly 125 times as great as that of an armature section, each being ·01245 ohm. In this case $a = 1\cdot25$, $b = \cdot1$, $g = o$.

The curves D, *d* refer to the case when no armature connections are used, and the value of r is increased to five times its former value by inserting resistance in the body of the brush without altering the contact surface resistance. In this case $a = \cdot005$, $b = \cdot5$, $g = 1$.

§ 17.—To compare the curves of fig. 14, it may be remarked that with perfect commutation heat is developed in the armature connections at each commutation point at a rate which has a mean value $4\,C^2 \times \frac{1}{3}\rho$ for the whole commutation period: where $2\,C$ is the total current collected at the point, and ρ is the resistance of each armature connection. Also heat is developed under the same conditions in the brush at a rate $4\,C^2 \times r$; where r is the brush resistance. The sum of the two quantities r and $\frac{1}{3}\rho$ is tabulated below for each case as a measure of energy wasted in commutation resistance.

The most important quantities shown by these curves are the values of the ordinates just before the contact is broken, when the arc is struck; and the product of the current passing at that instant by the fall of potential may perhaps be taken as the measure, for purposes of comparison, of the destructive power of that arc. The values given by the ordinates of these curves have to be added to or subtracted from the values for perfect commutation according as the commutating field is in defect or excess, and in the table below is given the value of that product in each case for an instant, $\frac{1}{100000}$th of a second, before the contact is broken. At this instant the fall of potential from brush to commutator for perfect collection is ·2 volt, and the current passing is 1 ampere. These quantities are to be added to or subtracted from those due to field error according as the latter is in defect or excess.

Case.	$r + \frac{1}{3}\rho$, the measure of energy wasted in commutation resistance.	Product of current and fall of potential at the instant before contact is broken, the measure of the energy of the arc.	
		Field 10 per cent. in defect.	Field 10 per cent. in excess.
A *a*	·001	33	24
B, *b*	·001 + $\frac{1}{3}$ 002 = ·0017	24	16
C, *c*	·001 + $\frac{1}{3}$ 0125 = ·0052	7·2	3·2
D, *d*	·005	1·8	·2

The second case shows that no considerable improvement is effected on the first case by using additional armature resistance to absorb ·26 per cent. of the power of the machine. A comparison of the last two cases, in both of which 1·5 per cent. of the power of the machine is wasted in extra resistance, shows that during the greater part of the commutation period the armature connection resistance reduces the effect of the field error more than does the brush resistance; but that the latter is by far the most efficient at the moment when the action is most important, viz., just before breaking contact. The crossing of the curves C D, and *c d*, a little before the position V, illustrates the peculiar efficiency of carbon brushes.

§ 18.—It is a matter of common experience that the collection is improved by increasing the number of commutator sections. The reason of this is clear on referring to the analysis of § 14. The value of γ is a function of three quantities, a, b, g. It is reduced by any increase in the value either of a or b; and is increased in direct proportion by an increase of g. For good collection a and b should be as large as possible, and g as small as possible. Now $a = \frac{R}{n} \cdot \frac{T}{l}$ (omitting armature connections), $b = \frac{2r}{n^2} \cdot \frac{T}{l}$, and $g = \frac{f}{n} \cdot \frac{T}{l}$. If the armature sections are reduced, and the number of turns to a section increased in the proportion, say, of $n : m$; and if the thickness of the brush, and in consequence the value of T, is unaltered; then a and g are reduced in the proportion of $m : n$, and b is reduced in the proportion of $n^2 : m^2$. A little consideration of the curves of fig. 14 shows that this must be disadvantageous to the collection if m is $> n$. If, again, the thickness of the brush be increased to the width of one of the new commutator bars, and correspondingly reduced in width so as to keep r unchanged, T will be increased in the ratio $n : m$. Now

a and g have their original values, while b bears the ratio $n : m$ of the old value. This is still disadvantageous to the collection.

(*To be continued.*)

ECONOMY OF INJECTORS.

There can be no boiler feed pump so economical as the injector if the temperature of the feed water is sufficiently high to admit of the use of an injector. But there are not many power stations wherein the injector is a really legitimate feed apparatus. In a non-condensing station the waste steam applied to the feed water in a coil is sufficient to heat the feed to 212°. The injector will not do this, but will feed at about 190°, and, moreover, it is, so far as it goes, an economical instrument, for all the heat that goes into the injector either becomes converted into the necessary work of forcing water into the boiler, or appears as heat again in the boiler. There is no waste. If exhaust steam has a sale the injector is a good boiler feeder. It is cheaper, also, to use condensing engines than it is to use the steam in a feed-heater coil, but the feed water should still be sent through a coil in the exhaust main between the engine and the condenser on its way to the boiler, and should also be heated by a live steam coil in the absence of an economiser before entering the boiler. In this connection we feel disposed to condemn the use of the perforated feed pipe where the feed water has much carbonate in solution. A carbonate feed water heated well towards 212° in the economiser will quickly choke the internal feed pipe of a high pressure, and, therefore, high temperature boiler, owing to the deposit of the lime salt as soon as the temperature of 212° has been acquired by the entering water, which occurs before it escapes at the perforations of the internal pipe.

It is probable that an open trough in the boiler, as suggested by some writers, would give better results, the feed water depositing its salts in the trough instead of choking the perforations of the steam pipe. Much controversy has raged round the injector. In the first place, its action has been looked upon as somewhat mysterious because it has no moving parts, and the conventional engineering mind could not see clearly the action of a steam engine without a piston. Mechanically, engineers saw the advantages of a rotary engine, but they crippled their correct theory by insisting on a piston, until Parsons came forward, and, without pistons in his turbines, which we believe have now taken the highest position in kilowatt-hours per pound of steam yet attained in the generation of electrical energy, he has made a rotary engine that is, up to a point, perfect. Had the kinetic theory of gases been earlier promulgated, it would have perhaps sooner appeared plain that the injector was a very simple application of the theory to practice. Nothing is more ideally simple than the kinetic theory of gases. Applied even to piston engines, it explains the transformation of heat into work upon a moving piston in a far clearer manner than any other attempted explanation, and it fits the action of the injector to a nicety. It affords, moreover, the same clear insight into the action of the exhaust injector, which has not been employed to the extent that it deserves. Indeed, we have known men refuse to employ the exhaust injector in the most fitting circumstances, because they themselves—little tin gods—could not see how such a thing could work with exhaust steam. Exactly the same reasons are advanced against the use of electricity, of blast furnace gas for motive power, and a hundred other things, and the mental atrophy of the rich men of this country is responsible for any amount of industrial lethargy, for the difficulty of introducing sound ideas, and the ease with which unprincipled men foist rotten ideas upon the public.

Reasoning on the basis of the kinetic theory, the action of the injector consists simply in affording a free orifice for the escape of the molecules of steam at the velocity they possess at the steam temperature. The molecular velocity of water vapour at 0° C. is 566 metre seconds, and the energy of movement increases with temperature. The steam molecules share their kinetic energy with those of the water that are brought into parallel with the flow of the steam. A mean combined velocity results which exceeds the velocity of outflow of water at the boiler pressure. The jet enters the boiler by virtue of its superior velocity, and the energy of the jet is concentrated upon so small an area of cross-section that its advance cannot be checked by the boiler pressure, which simply means that there are not sufficient molecules bombarding any area of the size of the jet cross-section to drive the jet back again. As the reduction of temperature measures the amount of kinetic energy destroyed, it is easy to see that the colder the supply of water to an injector, the more effective will be energy transference, for more steam molecules will be deprived of heat and their energy given to the combined jet.

The following practical figures are given by Mr. Hortz of the performance of well-made injectors. To premise, all injectors are numbered by the diameter of the injection nozzle at its smallest section expressed in millimetres. This arose from the fact that the injector was invented by Giffard, a Frenchman, and it was, of course, measured in millimetres, and the first English makers, Sharp, Stewart & Co., followed the same practice. Of the heat of the steam practically one-fifth is used in work and four-fifths go to raising the temperature of the water. Obviously when the water jet has an energy in excess of that necessary to enter the boiler, as it always has and often to a considerable amount, the entering jet of water produces eddies inside the boiler and finally comes to rest by fluid friction. There is no loss here; the surplus energy again appears as heat and helps to raise the general temperature of the water in the boiler. The water delivered will be 9 to 14 times the weight of steam used. At a delivery temperature of 150° the ratio of water to steam will be 12; at 260° it will only be about 5. To clean injectors of the lime deposit which so often accumulates in them, the brass parts may be placed in 1 to 10 diluted hydrochloric acid until "boiling" ceases, but Mr. Hortz recommends the use of reamers borrowed from the makers. We fear few makers would lend such tools, and we doubt the method as the risk of damage is too great. The acid method is good if the injector parts are of gun-metal, as they should be.

The author might have added that many of the modern injectors are put together far too slightly, and are badly arranged for pulling apart, and very apt to be broken at cast-iron screwed body joints.

We have found flake graphite and mineral oil a useful smear on all parts before putting together. Dixon's smear grease, as it is called, is the best material to use, and is probably compounded somewhat as above. It is useful for all manner of screwed joints, and avoids the pernicious effects of paints.

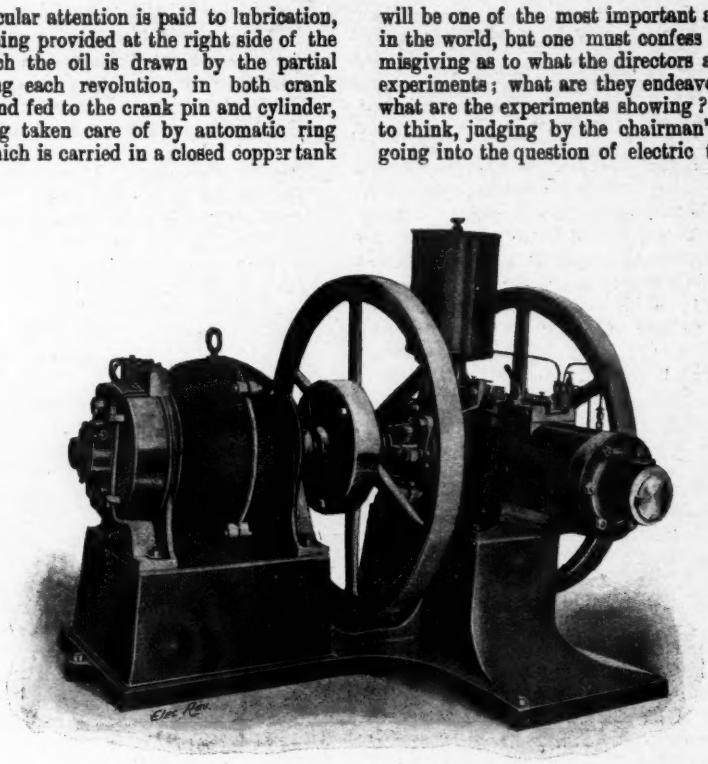
W. H. B.

OIL ENGINE WITH DIRECT-CONNECTED GENERATOR.

For many years, says the New York *Scientific American*, Europe was ahead of America in its use of gas and oil engines, while the latter country led the world in the development of electricity and the construction and use of electric machinery. To-day, however, there is a growing appreciation of the economic merits and wide range of application of the former types of motive power, and the firms which were early in the field in the design and construction of gas and oil engines have their hands full in keeping pace with the demand. The merits of the gas engine are well understood, and the same advantages of low first cost, ease of application and handling, and cleanliness, render the oil engine an ideal prime mover where small units of power are required, while the cost of operation is greatly reduced.

We herewith illustrate a Mietz & Weiss engine which consumes the ordinary kerosene of commerce. These engines are made in eight sizes, ranging from 1 up to 20 H.P. The 1 H.P. engine weighs 600 lbs., and covers 30 × 36 inches of floor space, while the 20 H.P. engine calls for 60 × 90 inches and weighs 6,500 lbs. The engine illustrated is of 4 H.P. and is direct-connected to a generator which is mounted upon a common base, and has a capacity of 40 16-C.P. incandescent lamps. As the engine is of the two-cycle type, with an explosion at each revolution, it is susceptible of a more perfect regulation than the four-cycle engine. The crankshaft is entirely enclosed, with a view to excluding

dust and dirt, and particular attention is paid to lubrication, a special oil reservoir being provided at the right side of the engine frame, from which the oil is drawn by the partial vacuum formed, during each revolution, in both crank chamber and cylinder, and fed to the crank pin and cylinder, the main bearings being taken care of by automatic ring oilers. The kerosene, which is carried in a closed copper tank firmly screwed to the cylinder, has a capacity of 10 hours' run. The consumption is about three-quarters of a pint per H.P.-hour.



The oil is fed from the tank to the cylinder by a small oil pump, operated by an eccentric on the main shaft, an injection of oil taking place at each revolution. The place of the throttle in a gas engine is taken by a little hinged finger on the plunger of the oil pump. When it is desired to stop the engine, the latch is thrown up, clear of the follower, and the pump is thereby thrown out of operation. The amount of oil fed to the cylinder is controlled by a simple and effective governor.

The direct connecting of a generator to an oil engine calls for a certain measure of elasticity in the coupling, although, as already explained, the fact that an impulse is given at each revolution secures a very even running in these engines. In the coupling the power is transmitted through three studs provided with rubber rings which are of sufficient strength to carry more than the required load, and serve to absorb all shock and ease the strains due to sudden variations of load, or to the irregularity in the alignment of the engine and dynamo. The engines are built by August Mietz, of New York City.

ELECTRIC TRACTION EXPERIMENTS IN LONDON.

WHATEVER may have been the views of the shareholders of the Metropolitan Railway Company with reference to the statement of the chairman regarding the electric propulsion experiments now in operation, we confess to a feeling of dissatisfaction. We are told that certain trials have been made, but further tests are necessary before the directors can decide upon the question. It might, however, be as well to quote the chairman's remarks before making any comments; they are as follows:—

> In regard to the experiments in electrical traction between Earl's Court and High Street, Kensington, the board felt some disappointment that those experiments had not yet been completed, and that they were therefore unable to make any definite statement in regard to the result. The shareholders, however, might rest assured that the question of the adoption of electric traction was exercising the board's very careful attention, and he might state that they had tried other experiments on a piece of line at Wembley Park, which, so far as they had gone, had given the directors and officials an amount of valuable information that would assist, materially, in solving the difficulties in the way of applying electrical traction to the working of the company's railway. They also considered that those additional experiments had been valuable in training the engineering staff at Neasden, in the use of the new tractive power.

Of course, there can be little doubt that if electricity is eventually applied to working the Metropolitan Railway, it will be one of the most important applications of electricity in the world, but one must confess to a certain amount of misgiving as to what the directors are doing in the way of experiments; what are they endeavouring to arrive at, and what are the experiments showing? One is almost inclined to think, judging by the chairman's remarks, that they are going into the question of electric traction *de novo*, without much reference to what has been already accomplished in the United States, in Europe, and particularly in our own country.

Even if one were to study only the electric underground railways of London, there is a vast fund of information and data, much of which could be readily applied to the problems of the Metropolitan Railway. Save for the tributary lines of the latter, there do not appear to be any marked differences between the requirements of the City and South London Railway and those of the Metropolitan. It may be that the advisers of the latter concern have carefully studied the various electric railway systems of the world, and that they are perfectly acquainted with what has been done with the three-phase system in Switzerland, with the multiple unit system of the Chicago line, and the numerous branch and light railways of America. We are not suggesting that the directors of the Metropolitan Railway are not justified in being cautious in a scheme that may involve a great expenditure, but on the other hand, an excess of caution may result in elementary experiments, and it is in this direction that the greatest danger is to be feared. It is apparent that the directors of the Metropolitan Railway do not consider that the Earl's Court experiments are going to be conclusive enough, or they would have hardly started a fresh set of experiments at Wembley Park. We do know for a fact that whatever results may have been achieved at Wembley, the experiments have been of a most restricted nature, and that being so, it is rather difficult to comprehend that much information could be gained which "would assist materially in solving the difficulties in the way of applying electrical traction to the company's railway."

We have always understood that some of the special difficulties of the Metropolitan system were the underground tunnels and cross-overs, but how could the Wembley experiments help to solve those problems? There are no tunnels and no branch lines at Wembley, and, as far as we can see, the only end for experiments there would be to determine the various details of the electrical equipment according to the work to be accomplished. But all those questions have been fully worked out, and the results are available to anyone. As far as we have seen the sample system at Earl's Court, there is no departure from previous practice, but electrical engineers who are familiar with traction questions could tell exactly what such a system would accomplish without troubling to put down plant. It could hardly be urged that traffic problems were to be considered, for the line between High Street, Kensington, and Earl's Court would hardly aid in solving them. Considering that the Central London Railway will shortly be available for traffic, that the Waterloo and City is a conspicuous success, and that other underground electric railways are in progress, the policy of the Metropolitan Company would appear to be a halting one. We admit there may be some difference between the Metropolitan and the other systems, and, moreover, the length of line is

quite incomparable, but any problems that may arise from these causes cannot be solved by small experiments at Earl's Court and Wembley. Supposing the experiments at these places are not satisfactory to the directors of the Metropolitan Company, will they then decide that electricity cannot be applied to the underground railway; or will they adopt electrical working in spite of the inconclusive nature of the experiments? If they adopt such a course, they will lay themselves open to the charge of making unnecessary experiments, and if they determine not to use electrical methods they must, in accordance with the recommendation of a Parliamentary Committee, find some adequate means of ventilating the tunnels, the condition of which is daily growing worse. The position is one of some difficulty, and is not likely to be improved if a strong attitude is not adopted.

PROFESSIONAL PUSH.

There can be no occupation more honourable than that of the engineer, namely, the subjugation of the forces of nature to the use of mankind. To be able to do this is the distinctive character of the human intellect, and it is the business of the engineer to do it systematically, in the highest degree, and on the largest scale. *Ex opere artifex.* There ought to be no possible question as to the action and position of those who have been instrumental in carrying out the material triumphs of modern civilisation.

This is the theory, very pretty like most theories, but for a long time the facts corresponded to it. Of the canal makers, of the early railway makers, of the trainers of river and tideway, and the builders of docks and dams, whatever might be their origin or education, no one could be in doubt as to their true position or the integrity of their works. Is it then to be reserved for an age in which all men are educated, and for the latest born and most highly technical of the various branches of engineering to falsify the theory? The facts are unpleasant.

Civil engineering has been a profession with a strong sense of dignity, and it has seemed as impossible for a civil engineer to tout about for business as it would be for a barrister or a doctor. In electrical engineering we have not yet come to open advertising after the style of the music-hall "star," though even this would be less objectionable than some of the practices now commonly indulged in, to procure a practice of another kind. Short of this, however, all considerations seem to have been thrown to the winds and the chase of the nimble guinea is indulged in by methods most unsportsmanlike and destructive of the general welfare.

Formerly, when electricity was not taken seriously, and electrical machines were apparatus for giving you a shock, there was a certain breed of "medical electrician" who was a compound of the charlatan and the cheap jack. The qualification was to have no knowledge of either medicine or electricity, but a profound appreciation of the credulity of the public. Such people maintained an ignominious existence by exploiting the ignorant prejudices of the community, but never even when their impudence was at its loftiest flight did it occur to them to style their miserable trade a profession. Yet, after all, did they do anything that was ethically distinguishable from what is being done by many consulting engineers, who could scarcely conceive it possible that they should be mentioned in the same breath as these quacks? Each alike takes the money of the ignorant, and each alike gives in return something which, if he has the knowledge to which he lays claim, he must be well aware cannot fulfil the promises made to the credulous purchaser.

When it comes to facts, there are few local authorities that can discuss the question of electric lighting without forthwith receiving touting letters asking for the appointment as "electrical expert" or "consulting engineer," as it is variously phrased.

The fee asked for a preliminary report may be anything or nothing. There are cases where a report gratis has actually been offered.

Of course the men who do this are not likely to discover insuperable obstacles in the way of carrying out any fad that may commend itself to the untaught ideas of the town councillor. It is unfortunate alike for the reputation of municipal enterprise and the future of electrical engineering that, generally speaking, the local authorities should be so liable to the infection of claptrap. On every Council there are men on the look-out for "a scheme,"—something to bring forward and attract attention. The serious duties of the Public Health Act, and other far-reaching measures, the earnest routine of * municipal life, these are not sufficiently picturesque for their restive minds, and do not make for prominence at the local clubs and pubs. The worst of it is that the unfittest survive, whilst their proceedings deter the sounder men from taking part in municipal work. When the thing proves itself wrong, their errors do not follow them very far. They may miss a term or two on the Council, but, in any event, there is no personal liability. These gentlemen have "called the tune," but the ratepayers "pay the piper." Compared with the way a mere Board of Guardians may get surcharged and be made individually liable over a £6 item, it is just a little ridiculous.

It is from this class of delegate that the touting expert meets with his greatest support. An idea that has been fashionable among them lately is "Combined Dust Destructor and Electric Lighting." It is not exactly something out of nothing, but it is so near to it that there is little to choose. They ask for some philosopher's stone that will convert dross into gold, canals into cataracts, and cabbage stalks into coal. The absolutely newest is tidal power, but fortunately that cannot spread inland. In pursuit of the *ignis fatuis* of unpaid-for power, there is nothing they will not ask for—and get. So that one really hesitates to mention other possible, but as yet, unadopted absurdities, for fear of finding them come at once into vogue.

In catering for this class, estimates must, of course, be adapted for popularity, and must therefore show an early profit. The following is an example of how it is done:—There is no justice or advantage in gibbeting one particular case, which is no worse than a dozen others, and therefore as the number of electric lighting stations is still limited, a scheme shall be taken which, as it happened, got such a dressing down that it will not be recognised. First of all a good round number of lamps is taken as being certain to come on from the start. Then it is assumed that each of these will bring in —sh. a year, if the price is not higher than so much. From this the annual output is calculated. The necessary plant for this output is pretty roughly estimated for (engines, boilers, machinery, &c., lumped together in one item), but the cost of working the station is calculated, not on the cost of running this plant so many hours, but at so much per unit (being about the average for all the stations in the country), as though this varied strictly in proportion to the annual output. By means of a little adjustment, it will be readily seen that a profit can be shown from the opening. The town councillor rarely sees that the profit brought out at the end is really assumed in the middle of the calculation.

That is the simple and easy way to do it, and so long as that pays better than a better way, that is the way in which it will be done. Of course, when a Council has any particular fad, like a dust destructor, or the utilisation of existing sites, buildings, or water-powers, in conjunction with the electric lighting, it is not quite so easy, because it has to be determined which of the two is to be made to pay at the expense of the other. But in any event it is more prudent, from the point of view of both parties, to get in some public

* "The spheres of municipal action are almost limitless. Here are some—and but a few—of the subjects on which plenary powers have been conferred on our municipal authorities, and I ask you, as I enumerate them, to note how closely they bear on the moral condition of the men and women of our towns: The housing of the people, the protection of infant life, the preservation of health, the prevention of disease, the control of common lodging-houses, the safeguarding of the worker, the control of the police (and, through them, the suppression of crime and vice in their many shapes and forms, and the enforcement of the liquor laws), the securing of the purity of food and drugs, the maintenance of just weights and measures, and, finally, by means of the latest statute of all, the reformation of the criminal drunkard. . . . What a catalogue of opportunities is here. . . . . ."—From "The Relation of Municipal Action to Morals," by Mr. Alfred T. Davies, Cursitor of the County Palatine of Lancaster.

lighting, if possible, because the cost of running arc lamps is a thing that no one can determine without a knowledge of the financial state of the station. At least, one London Vestry seems to think itself justified in paying to itself out of the rates, about £38 or £40 per lamp, while in the country, where things can only be done on a small scale, and, therefore, come dearer apiece, we have arcs estimated for at as low as £16. The wicked companies that merely seek to make 5 or 6 per cent. profit and don't care a pin how bad the municipal accounts look, usually tender for the job at about £20 to £25. In fact, properly applied, public lighting is as great a boon in smoothing out the finance, as a battery in smoothing out the load.

In general, of course, there is universal agreement that in this electric century one should take opportunism to be the correct attitude, and there can be nothing more advisable than to take "short views." It is clearly best to prefer the certain good of those we know to the unpractical ideal of professional honour or the problematical benefit to the pockets of a ratepaying posterity. Therefore, if one should manage to be called in to advise by the local authority of quite a small place hanging on to the skirts of a big town, of which, of course, it is inordinately jealous, or of one of a group of little places, it is most unwise to trouble oneself with such considerations as whether the little town would not do much better to ask the big town to supply it with energy in bulk, or whether a company that could take in hand all the little towns and group them together, working each for what it was worth, without regard to local prejudices and jealousies, could not supply at about half the rate that any one of the little towns could do for itself. When one has become a great man, with large offices in Blank Street, it will be quite time enough to go in for this sort of thing, and by that time, too, other people will have done it, at any rate, in America and on the Continent, and the difficulty of copying them will not be nearly so great as designing the thing oneself for the first time. Moreover, the councillors want to have the thing in their own hands, and will be glad to be advised that they should keep it so. Why should any practical man put himself out of the way to disoblige his customer and lose his job just for the good of the town? The town will never be grateful. In every way there can be no doubt in advising:—"I am firmly convinced that the Council should keep the supply of electricity in its own hands." To say anything else would be as quixotic as to predict a deficit on the first two or three years' working. A patriotic councillor is, of course, convinced that his gallant little town is as good as any other town, and it would be positive rudeness to tell him that it cannot do better. The consultant really knows little or nothing about the town, and if he is assured that there are peculiar circumstances of superiority about the place, it is his obvious duty to accept the matured opinion of people who have lived nowhere else all their lives, and therefore are in a position to know all about it. At any rate, it is not his fault when his estimate of profit is not fulfilled.

This, then, is the way to do it, but if things are to continue on their present course, a younger generation will have to go a little further and give rather more for rather less. The smaller a town the more it expects, and the towns that are left are getting very small now. Whether the coming-on young gentleman will be equal to the occasion, or whether it will occur to someone that the line must be drawn somewhere, remains to be seen. If not, the prospect appears to be that the country will be dotted with toy stations at the rate of one per parish, each producing its annual deficit, dear electricity will remain for ever, the resident electrical engineer will be rewarded with £1 4s. a week and the consciousness of virtue, while the consultant—well, people with any reputation to lose will keep explaining that though they understand electricity and engineering, and can give advice, plans and estimates, they are not, and will not be called, "electrical engineers."

The Royal Society.—The papers read yesterday afternoon included one by W. C. Henderson, "On Electrical Effects due to Evaporation of Sodium in Air and other Gases;" and one by Prof. J. C. Bose, "On Electric *Touch* and the Molecular Changes produced in Matter by Electric Waves."

LEYTON ELECTRIC LIGHT EXTENSIONS.

On Saturday last, February 3rd, the chairman of the Electric Lighting Committee, Mr. C. G. Musgrave, laid the memorial stone of the new buildings at the electric lighting works, Cathall Road, Leyton. Mr. Musgrave gave an interesting account of the steps taken by the District Council since the grant of their provisional order in 1894. The existing plant is one of the few in which gas engines are employed, and as far as it existed at that time, will be found described in our issue of November 20th, 1896. Additions were made in 1897, 1898, and 1899, both of buildings and machinery, but before these were completed it was found that further development was compulsory, and the late electrical engineer to the Council, Mr. Bishop, before leaving for Wigan in the early part of last year, prepared a scheme for further extensions.

By this time it had become manifest that in connection with any further addition to the machinery it would be necessary to have a steam generating plant. We are informed that the vexatious delays in connection with the delivery of the gas generating plant, the comparatively small load which could be carried even by the larger of the gas engines, the constant interruption caused by temporary breakdowns, which, as the station was now worked to its utmost capacity, at once affected the quality of the light, all pointed to a change in the nature of the generating plant. Accordingly one of the first duties which the present electrical engineer, Mr. F. Harman Lewis, had to turn his attention to was the development of this extension scheme. He suggested the acquisition of four large steam engines, with dynamos and boilers and large additional service of mains and feeders. This scheme, which necessitated the purchase of additional land for the erection of new buildings was estimated to cost a further sum of £30,000. The report was approved by the Electric Lighting Committee on March 22nd, and confirmed by the Council on April 6th last. Tenders were invited for the erection of the various works, and contracts were entered into with Mr. Coxhead for the buildings and chimney shaft, Messrs. Willans and Robinson for the four triple compound steam engines, Messrs. Mather & Platt for the dynamos, Messrs. Davey, Paxman & Co. for the boilers, and Callender's Cable and Construction Company for the mains and feeders.

The cost of the station and works when the present extensions are completed will be about £80,000, with a capacity of upwards of 45,000 lights instead of the 6,000 lights allowed for by Prof. Robinson in the larger of his two estimates in 1895, which he anticipated would be sufficient for five years.

On January 1st, 1897, the charge for current was reduced from 6d. to 5d. per unit, and in the case of large consumers to 4d., and in March, 1898, the Brighton system was adopted, 5d. per unit being charged for the first hour and a half, and 2d. per unit for all current used afterwards.

During the last quarter of 1899, 145,575 units were sold, of which 97,149 were to private consumers, and the remaining 48,426 were for the public lamps. Of these 97,149 units, 50,589 were sold at 5d., and 43,243 were sold at 2d., so that the average cost to the private consumer works out at a trifle over 3½d. per unit, as the analysis shows that at Leyton during a winter quarter, nearly as many units are consumed on the 2d. scale as on the 5d.

A CRITICISM OF MECHANICAL STOKERS.

One of the undesirable results of smoke prosecutions is the production of a flock of useless devices in the shape of patent firebars, bridges, and other details. Mr. Goodrich, in the *Engineering Times*, rightly declares at least 75 per cent. of so-called smoke preventing devices to be worthless. Steam users, who are not themselves trained engineers, are very apt to be taken in by the worthless devices, and to reject what would be of real value to them. An American writer has said that no device is worth trying unless it will save its cost in four years. Mr. Goodrich expresses himself favourably to mechanical stokers as generally successful as smoke preventers, though only where the work demanded

from a boiler is reduced to two-thirds what should be ordinarily expected. This he looks on as the special weakness of coking-type stokers. Further, the coker is an ugly, cumbersome, noisy, and costly machine—an indictment, we think, that will be generally considered somewhat overdone, more especially as regards noise, for the sprinkling stoker is more noisy. The sprinkler is described as a far more efficient machine, but less successful as a smoke preventer, and the author does not overlook that very serious fault in these stokers—the out-pouring of dust from the chimney tops, especially where the draught is good. The draught exercises a winnowing effect upon the fuel as it flies from the shovels to the fire surface and carries the lighter dust direct over the bridge, exactly, though to a less extent, as happens in the Wegener system of firing finely-powdered coal—a system sound enough in principle, but impossible unless special depositing chambers are provided to obviate the difficulty. The difficulty is one not merely impossible to allow in a city, but one that is impossible in connection with many industries.

It is correctly pointed out that the innocent little steam jets so often applied to keep the bars cool may consume as much as 8 per cent. of the total steam produced by the boiler. The device is also of very little service.

The special fire bars so much employed are also condemned as useless.

The future stoker should be capable of being attached to the boiler without drilling holes in the boiler front. The fire doors ought to be of such size that hand firing ought still to be possible when the machine fails. The doors so far provided in mechanical stokers have been ridiculously small; they render hand stoking difficult and furnace inspection practically impossible. No stoker, it is claimed, can be of any use unless the draught is good; it is, therefore, useless to attempt to cure a poor draught by employing a machine stoker. Too good a draught is also an undesirable feature, because the great difficulty with mechanical stokers is the uneven layer of fuel on the grate and the great volume of air which rushes into the furnace in consequence. On account of the troubles which arise, evidently due, in the author's opinion, almost entirely to poor draught, and which result in excessive heat at the furnace front and cracked castings with overheated bearings, Mr. Goodrich believes that success must be sought in a combined stoker and mechanical draught, and he recommends a certain make of stoker with which it is possible in an 8-inch Lancashire boiler to burn fuel at the rate of 55 lbs. per square foot per hour. The draught is forced by blowers under the grate, and as the firm supplying the stoker are noted for using steam blowers, it would appear that the author is recommending what he has just been condemning, namely, the steam jet. The firebars are reciprocating, and the whole machine is suspended from the top of the boiler front. Mr. Goodrich is specially careful to say that he has no bias in favour of this machine, which he claims has given from 12 to 14 per cent. of CO_2 in the flue gases.

It is because of the many difficulties we recognise in mechanical stoking that we see at present very little prospect of real success for any system that does not employ the force of gravity to assist the fuel movements. Externally fired boilers alone appear to possess the facilities necessary for such application, and as external firing is a doubtful expedient in shell boilers, the application of mechanical stoking in such boilers is likely to be chiefly successful where special outside furnaces are employed.

THE HOPKINSON MEMORIAL AT CAMBRIDGE.

The resources of the engineering school at Cambridge received a great increase on Friday last by the opening of the John Hopkinson memorial wing, which has been erected by Mrs. Hopkinson and her son and daughter to the memory of Dr. Hopkinson and his son, John Gustave Hopkinson, who lost their lives on the Alps two years ago. The engineering school at Cambridge has grown so largely in the last few years, numbering now some 150 students, that the old accommodation provided (largely by public subscription) when Prof. Ewing was appointed to the Chair of Mechanism, had grown to be altogether inadequate for the actual needs. The munificent gift of Mrs. Hopkinson has thus come at the right time, and will be of the utmost importance to the study of engineering at Cambridge. The former buildings consist of a drawing office, mechanical, electrical, and heat engine laboratories, with a museum, lecture room, and private rooms; the additions include a large laboratory devoted to elasticity and hydraulics, an additional class room and drawing office, a lecture room, dynamo room, and rooms for research students, whose work in the engineering laboratories has resulted already in two important papers presented to the Royal Society. The laboratories are very completely equipped with various forms of steam, gas, and oil engines, turbine, centrifugal pump, &c., testing machines, dynamos with direct current, alternate, and three-phase, together with very numerous apparatus for general experiments in the various departments of engineering, mechanical, civil, and electrical. Altogether the School of Engineering is one of the best equipped in the kingdom, and its efficacy is witnessed by the great number of men it is attracting to Cambridge. A short account of the opening ceremony is appended:—

The opening ceremony took place last Friday in the large new hall, where an inaugurative address was delivered by Lord Kelvin. Afterwards the Master of Trinity unveiled a portrait of the late Dr. Hopkinson, presented to the laboratory by subscribers.

The Vice-Chancellor (Mr. W. Chawner, Master of Emmanuel College) said it was a remarkable testimony to the importance attached by public opinion in England to the application of the highest scientific and mathematical knowledge in all practical studies, that the engineering department should have received such large encouragement and so many donations from friends outside. Of the total cost, £12,500, no less than £11,000 had been contributed by donors. In the course of further remarks the Vice-Chancellor said that, knowing Hopkinson's father when he was Mayor of Manchester, he was happy that it had fallen to his lot to convey to Mrs. Hopkinson the assurance of their sympathy and of their gratitude to her and her children for this noble benefaction with which they had enriched the University in the name of husband and father.

Lord Kelvin said the opening of the John Hopkinson memorial wing of the engineering laboratory was an event of the deepest interest, and of manifestly high importance in the history of the University of Cambridge. John Hopkinson showed to quite an exceptional degree the rare power of grasping a high scientific truth, and applying it practically to mechanical art for the use of mankind. This was splendidly illustrated in the work which he did in improving the dynamo-electric machines, upon which we depended so much for light and power. Then there was his great discovery of a certain alloy of nickel and steel. The limits of time forbade description of his scientific and engineering work. But mention must be made of the Bessbrook Electric Railway in County Down, designed and carried out by his brother Edward, which was the first in the kingdom, and had been in working order for 15 years. John Hopkinson devoted himself enthusiastically to the work of civil engineering, and for fully 25 years of his life he gave great assistance in a large number of directions. Hopkinson's group-flashing light, a splendid application of scientific optics, was now in use in lighthouses and lightships all over the world. Everything that was for the good of clients, of engineers, and of the engineering profession itself Hopkinson had at heart. Not many years ago he founded a Volunteer corps of electrical engineers, and he (Lord Kelvin) was made honorary colonel of it. A section of that corps were now under orders to proceed to South Africa to apply electricity in any way that might be wanted, the search-light included, and all would wish them success. When Hopkinson was an undergraduate at Cambridge there was no physical laboratory, and probably he saw no experiments, except—and the exception was important—in the lecture-room of Sir George Stokes. Lord Kelvin was sure that Sir George was proud of his pupil's having turned his instruction to such good account. The Cavendish Laboratory, founded by the late Duke of Devonshire, Chancellor of the University, with its first professor, Clerk Maxwell, had added greatly to the fame of Cambridge as a place of research. Since then great things had been done for physical science in that school by Lord Rayleigh and Prof. J. J. Thomson. But still there was something wanting—the application of physical science to the wants of mankind, and that had now been supplied by the engineering laboratory. John Hopkinson was keenly interested in this school of engineering. He gave support and advice to its promoters in its very beginning. Good work had been achieved under its present distinguished chief, Prof. Ewing, whose books on (1) Magnetic Induction in Iron and other Metals, (2) The Steam Engine, and (3) The Strength of Materials, had proved extremely valuable contributions to physical and engineering science. Excellent work had also been done by students in the laboratory in virtue of the inspiration of the chief and under his guidance. Three of the exhibition scholars had chosen this engineering laboratory for their post-graduate work. The laboratory had grown largely, and there were now 150 students. Hopkinson always followed with the utmost interest its progress, and he knew the congestion was keenly felt. In August, 1898, he was in Switzerland with Mrs. Hopkinson and their family. Then and there it was arranged with Prof. Ewing to make a systematic effort to raise the funds necessary for the extension of the laboratory. In October of the same year Mrs. Hopkinson said, "I wish that thing to be done." Well, it had been done—by Mrs. Hopkinson, her son,

and daughter. In conclusion, Lord Kelvin said he had been deputed by the board of directors of the Linotype Company to offer for the acceptance of the University a bust of Dr. Hopkinson.

Prof. Ewing proposed a vote of thanks to Lord Kelvin, and spoke personally of his Lordship's inspiration and example. He thanked Mrs. Hopkinson and her son and daughter for what they had done, and also spoke of the many other gifts that had been received. Only that day he had by telegram received the promise of another valuable one from the Westinghouse Company, of America.

Principal H pkinson, of Owen's College, Manchester, seconded, and said he was pleased to hear the kind words of appreciation of the memorial of his brother.

The Master of Trinity then unveiled the portrait. It was pleasing to know that a replica of the picture had been offered to and accepted by Mrs. Hopkinson.

Mr. Bertram Hopkinson having thanked the donors of the portrait,

Sir Douglas Fox, President of the Institution of Civil Engineers, moved a vote of thanks to the Master of Trinity, and the proceedings terminated.

Prof. and Mrs. Ewing afterwards held an "At Home" in the laboratory.

ARNOLD MAGNETIC CLUTCH.

In the design of the modern electric power plant it is frequently found desirable to arrange the generators in such a way that they may be readily connected or disconnected to the prime movers according to the exigencies of the service. This requirement of successful power station design was early realised by Mr. Bion J. Arnold, of Chicago, a pioneer in this field of engineering, who recognised at the same time the limitations of the ordinary friction clutch for this purpose. Accordingly, some years ago, Mr. Arnold worked out a device which would meet modern requirements, and the result has been the development of the Arnold magnetic clutch, a number of which have already been built.

These clutches are in reality friction clutches, yet the friction between the contact surfaces is not due to mechanical pressure, but to magnetic traction. The working parts of the clutches are composed of metal having a high permeability so arranged as to become magnetised upon the passage of direct current through the coils with which they are provided. The two parts of the clutch can be attracted together in this way with a pressure far in excess of that obtained in mechanical clutches, and it is only a question of making the clutches large enough to enable them to transmit power in any desired amount. The energising circuit is controlled by means of a switch placed at a convenient point, which is quite a decided advantage over the ordinary friction clutch. It thus becomes possible in throwing a generator in or out of service to control it entirely from the switchboard, where all the regulating devices and measuring instruments are within the reach of one attendant. These magnetic clutches also possess the advantages of neat appearance and compact design. Even in the larger sizes the amount of space occupied upon the shaft is not much more than twice the diameter of the shaft, and by using a flange forged solid on the end of the shaft, they can be made to occupy even less space when used as cut-off couplings. Owing to their having no projecting surface or parts to catch the air when in operation the windage resistance is negligible. The greatest advantage, however, of this form of clutch over others is the fact that it is self-contained—the "action and reaction" being within the clutch itself, and consequently there is no resulting end thrust upon

Fig 1.

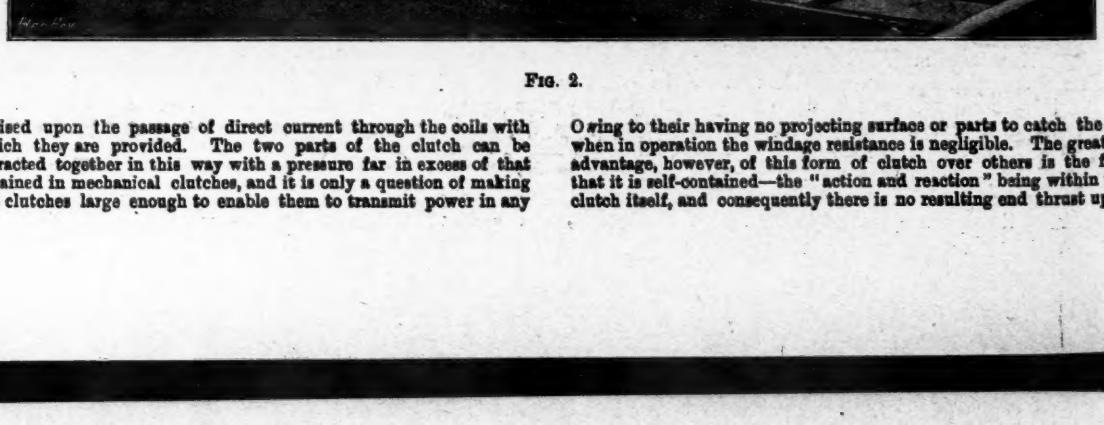


Fig. 2.

the shaft bearings and no additional friction load due to the operation of the clutch.

The illustration, fig. 1, shows the largest magnetic clutch in the world. It is 100 inches in diameter, and is capable of transmitting 3,000 H.P. at 150 revolutions per minute. This clutch is one of three now in use connecting the engines and generators in the central station of the Imperial Electric Light, Heat and Power Company at St. Louis, a view of the equipment of which is shown in fig. 2. The experience with this plant demonstrates that this form of clutch is applicable to the large size units now being installed for power station purposes, whereas the ordinary friction clutch becomes especially unwieldly and unsightly after passing the 500-H.P. size.

There seems to be no reason why a clutch of the type shown in the illustration cannot be substituted for the fly-wheel of the engine in many cases, thus making the weight and cost of the engine unit, fitted with magnetic clutches, but little more than the weight and cost of the small installation fitted with ordinary mechanical couplings.

The current is carried to the clutch coils through contact rings upon the side of the clutch, and carbon brushes held by insulated brush holders. The electrical connections are simple and easily accessible for inspection.

The unique feature of this clutch is the small amount of current needed. It requires no more than would be used by four 16-C.P. incandescent lamps, and the loss in the clutch due to the continuous use of the electric current, while the clutch is in operation, amounts to only one-hundredth of one per cent. of the power transmitting capacity.

Although these clutches were developed for use in connection with the "Arnold System" of power station construction, their application is in no way limited to the demands of this system, and they have been adapted and adopted for other purposes. A number have been made to connect large synchronous motors to their load in such a way that they can be quickly disconnected in case of accident, and they have also been built for use upon line shafting. It would seem that they were particularly applicable to use in connection with gas engines, and there is no doubt an excellent field for them here. They might eliminate the fly-wheel problem of the gas engine in many cases, which of itself would be a distinct advantage. Indeed, there would seem to be no limit to their use wherever it is desired to transmit power from one shaft to another.

SHOULD ELECTRICITY BE TAXED?

THE question of the dutiability of electricity transmitted from Canada to the United States having been raised, it is expected that the Treasury Department, where the important question is being considered, will render a decision that will not only announce the Government's position in the premises, but is also likely to be taken as a precedent by other countries where the influence of transmitted electric current is apt to be felt. It is not strange that this question should come up first in the United States Treasury Department, for undoubtedly the conditions now existing and prospective at Niagara Falls are what has brought the matter up. For this reason the decision that will be rendered will be of more importance in the immediate region of Niagara than any place else, but it will interest all manufacturers that come in competition with the product of the various large industries at Niagara Falls.

To gain an accurate idea of the situation, it will be well to review briefly the power development at the Falls. On the New York side of the river the Niagara Falls Power Company has expended several millions of dollars in the development of 50,000 H.P., and a second wheel-pit and power station of the same capacity has been started. Many industries are now using the developed force. The installation of the Niagara Falls Power Company as it stands to-day makes that company the largest producer of electricity in the United States. For this reason the position taken by this company on the question of imposing a duty on the transmitted current is interesting.

The same capital that is interested in the Niagara Falls Power Company has power rights on the Canadian side of the river under the name of the Canadian Niagara Power Company. This company is now sinking test holes in order to determine the nature of the rock through which its prospective tunnel will pass. A large development is contemplated. The public has always understood that when the development on both sides of the river was completed, the two stations would be connected by a cable line over which each plant would act as an auxiliary for the other. In this way, in case of severe accident to either of the plants, the current supply of the other plant could be turned on to perform the necessary service of power giving, or for use in the electro-chemical concerns which find Niagara such a popular place of location. These conditions make the situation of unusual interest. The Niagara Falls Power Company has only recently completed an eight-duct power conduit extending from its station to the upper steel arch bridge, and through this conduit cables are to be laid.

The Ontario Power Company is another factor in the situation. This company has a franchise from the Dominion Government to develop power on the Canadian side of the river, and while it has been falsely intimated that the Niagara Falls Power Company raised the duty question, it is now stated that the matter was brought to the attention of the Treasury Department officials by the Ontario Power Company. It is, of course, possible that this latter company sees a prospective competitor in the Niagara Falls Power Company or the Niagara Falls Hydraulic Power and Manufacturing Company, or that it feels by having an American connection the Canadian Niagara Power Company might find a better market for its product than it could find, for, at the best, there is but little demand for electric power on the Canadian side. By having the Treasury Department of the United States render a decision that electricity transmitted from Canada is properly dutiable, the Ontario Power Company might then carry the decision, as a precedent, to the Dominion Government, and ask that Government to take retaliatory legislation or make retaliatory rulings.

The position taken on the subject by the Niagara Falls Power Company is well outlined in the following letter:—

The Niagara Falls Power Company,
Niagara Falls, N.Y., *January 20th*, 1900.

The Honourable Secretary of the Treasury, Washington, D.C.

Mr. Secretary,—Having been informed by Assistant-Secretary Spaulding that a question in regard to the dutiability of electricity generated in Canada and transmitted to the United States is under consideration by the Treasury Department, I beg to inform you that the Niagara Falls Power Company, which is the largest producer of electricity in the United States, and which is now developing 50,000 E.H.P. at Niagara Falls, N.Y., where electricity generated in Canada and transmitted to the United States would come in direct competition with its generated power is opposed to the imposition of any such duty, and has taken official action upon this question.

I beg further to inform you that at a meeting of its board of directors held on the 19th day of January, 1900, the following resolution was unanimously adopted:

"Whereas, this board is informed that the Treasury Department of the United States is considering the question of the dutiability of electricity generated in Canada and transmitted to the United States, it is

"Resolved, that this company is opposed to the imposition of any duty upon electricity generated in Canada and transmitted to the United States; that it is the sense of this board that the imposition of such a duty is not required for the protection of any American industry, and also is objectionable as inviting retaliatory legislation or rulings by the Canadian Government."

Respectfully yours,
(Signed) W. B. RANKINE,
Second Vice-President.

—O. E. D.

LEGAL.

RUCKER *v.* THE LONDON ELECTRIC SUPPLY CORPORATION, LIMITED.

(*Continued from page* 172.)

SIXTH DAY, MONDAY, JANUARY 29TH.

THE hearing of the case was resumed on Monday, when Lord Kelvin, who had been examined on Friday, was cross-examined by Mr. Bousfield, Q.C. In answer to questions, Lord Kelvin said that the parallel arrangement with feeders was well known in 1885. They were feeders in a network.

Mr. BOUSFIELD: That was within an area not too great; that was a thoroughly practical system of distribution?

Lord KELVIN: Yes, within an area not too great.

As you extended your area, you would get your conductor larger and larger, and at a certain point it would become impracticable having regard to the cost of copper?—Yes; the object of the feeder arrangement is to keep the potential approximately uniform over a considerable area. The feeders might then lose a great deal of energy on the way.

Cross-examination continued:—The question of constancy of supply was a matter which was very important. In 1883, 1884, and 1885 incandescent lamps had been recognised as a practical mode of applying electric light for general purposes. For those it was necessary that the mains should be kept at a potential as nearly constant as possible. The desirability, if it were wanted to cover a large area, of being able to distribute at a high potential and use at a low potential was also recognised.

Mr. BOUSFIELD: And the means of doing it the only means of doing it which is recognised in the Act, I think—is by having storage batteries, secondary stations as it were with storage batteries, those storage batteries being charged by mains distributing at a high potential, and then a consumer's supply being taken off those storage batteries at a low potential?—That was a method which I am not aware was recognised in the Act, but it is a recognised method.

You took out a patent?—Yes. If I remember aright I also described at a meeting of the British Association at York, a method of charging a storage battery at a high tension, then coupling it up to give a supply at low tension, or divide it into parts.

Mr. BOUSFIELD: They must have had that in mind, because I find that in this Act there is this provision, for instance, that in charging these batteries at a high potential you are to disconnect them from the consumers' lines, and not put on the consumers' lines until you have disconnected at high potential and connected them at low potential?—That would be absolutely necessary, and I did myself patent an appliance for doing that systematically and automatically.

Before 1885?—Yes; it would be before 1885.

It would be before 1883. Having regard to the extension of electric lighting, it was a desideratum in those years before the patent to be able to distribute electricity to secondary stations. You know what I mean by that?—Yes.

To have a high potential, and then to transform in some way, so as to be able to use it at low potential?—Yes.

And this storage battery system, with charging and distributing mains, was a system which at that time might have given useful results?—Yes.

And it was adopted to some extent?—Not to a large degree; storage batteries were too costly.

And not reliable; they came to pieces?—At first they did.

There were many difficulties which one need not go into. In those years electricians—I do not know whether you personally were—but many electricians were hard at work in 1882, 1883, and 1885,

endeavouring if they could to find a better system for distributing electricity at high tension and utilising it at low tension?—Yes.

A great many discussions in learned and unlearned papers and at meetings of electrical engineers and so on. There were many discussions on the matter?—Yes.

I need not refer to them all, but the only one which stepped out of the area of experiment, so far as one knows, was that of Gaulard and Gibbs?—Yes, I believe so.

They had an idea, and they worked on the idea, that by the use of transformers, or coils, they hoped to solve the problem?—Yes.

And they initiated the system which we know was tried at the Aquarium, on the Metropolitan Railway, and other places. I do not know when the exact dates were—whether or not it was before 1885. It was tried, at any rate, on the Metropolitan Railway, and tried on a much larger scale at Turin, and that was before the year 1885 was it not?—Yes; that was a system of distributing by means of these transformers.

And they met with very partial success, did they not?—Yes.

You have told us that there was all this knowledge—everything which one wanted to know—to be found in various places. I daresay you had it all focussed in your mind?—No; I do not think much of alternating currents for working at great distances.

I am afraid you have misunderstood me. In using the word "focussed," I did not mean that you had brought it to bear on this problem. You have told us of all these little bits of information which were necessary, and which were to be found in a number of publications?—Yes.

I was going to give you credit for something new, and to suggest that the principal of all these little bits of information were in your mind. You knew of these things, did you not?—I did not know of Brush's suggestion; I did not know Edison's patent; I did not know the article describing Fuller's idea of lighting a town.

But still, as regards electrical principles, I suppose you would have at your fingers' ends all the electrical principles involved, whether by induction or anything else?—I knew what was known in the text-books.

I do not mean propositions like Fuller's or Edison's. I mean as regards principles?—Yes.

And I suppose there were others, though not many, perhaps, who were in the same position as yourself?—There were a good many people who knew all that was to be known from the text-books and from scientific papers.

And the desire of everybody being to get a practical system of distributing electricity at high tension and use it at low tension by means of transformers and otherwise, how was it that no one at this date had thought of this simple system of the plaintiff's patent?—Because I believe people were satisfied with the continuous current, and believed that continuous current would be better for all purposes than any other. I think many of the ablest electricians did not think it advisable to use the alternating current system even after it had been brought into use in very many important works in London and elsewhere.

But what I want to point out to you is this. The continuous current system, with a feeder arrangement such as there is in fig. 8, to which you can superadd Dr. Hopkinson's three-wire system, enabled you to solve the problem within a more or less limited area?—Yes, and by multiplying the central stations a very good result was obtained.

Of course that did very well with regard to multiplication of central stations, but when you had scattered consumers it would not do, would it? You could not put up a central station to supply a few odd consumers?—That is rather a difficult question. It would have been very much better, in the opinion of many, that a direct current should have been used in cases were an alternating current was actually used.

Are you still prejudiced in favour of direct current?—No, I am not prejudiced at all. The first installation I ever used at all was in my own college at Peterhouse, which was an alternating current.

I believe at that time direct current machines were hardly obtainable, were they, for giving a constant potential?—By 1883 they were obtainable. In 1881 and 1882 I think not. I remember in my own house I had great difficulty in getting a special favour from Siemens in 1881 to use direct current, but about two years after that the difficulty had ceased.

But in 1882 you had got an alternating machine?—No; I should have got a good Siemens then.

At all events, it was in those years, 1882, 1883, 1884, and 1885, recognised that the feeder system, even with a three-wire system superadded, only solved the problem of distribution practically within limited areas?—Limited to a great many miles.

Cross-examination continued: Fuller suggested using transformers with low tension mains in order to get a high tension in his lamps. That could be done, and the opposite could be done.

Referring to the specification, the WITNESS stated that the passage, "The apparatus for the actual utilisation of electricity, as incandescent and arc lamps, electro-motors, &c., are in all cases connected up in multiple arc in the local secondary circuits" was a useful piece of information. One of the commonest applications of electricity was to have four, five, or six mock candles for electric lights standing up looking like wax candles. There were, perhaps, 10 or 20-volt lamps and five of them in series from the mains, and in almost every house in London you would find a mixed series and a parallel system in the local secondary circuits. Gaulard and Gibbs had the lamps on the secondary circuit in parallel. The lamps would not be extinguished by short circuit.

Now, if you used transformers in the way proposed by Gaulard and Gibbs, the resistance in the coils of the transformer has nothing to do with self-regulation, has it?—I have not thought that out.

At all events, you agree as regards this matter of relative low resistance that it is a matter of vital importance in the construction of the coils under this system if you are to get the effect of having constant potential in your circuit?—It is no more important than in other electric dynamo machinery.

That is not my question. It may be of vast importance in others or not. But I ask you if it is not in this transformer arrangement system absolutely essential in order to get constant potential in your lamp circuits that you should obey this direction?—The word relatively does not occur.

It did occur at line 36 in the plaintiff's complete specification. It was very low at one place and relatively low in another?—That the resistance of the transformers must be relatively low.

Provided you have only three turns of wire and strength of induction it cannot be too low?—That is quite true.

In answer to further questions, Lord KELVIN said he supposed it was largely owing to his own influence as a practical electrician that the idea of distributing at high tension for electric lighting and using it at low tension was brought to the front. He had put forward that idea as an essential, as something necessary for transmission to a great distance, and in the Gaulard and Gibbs case he had said something to that effect.

Mr. BOUSFIELD: Your practical working out of that idea was to have secondary batteries charged at high tension, and from them to have consumers' mains at low tension?—That was the plan I proposed, I saw no other plan except step-down dynamos, that is, transforming down, using high tension power to drive a motor which gives low-tension power. My own idea was to do it by direct current. I had no idea then of doing it by alternating current.

Your idea was a high potential direct current to be used to drive a motor, which motor should drive a dynamo with a low potential?—I did not realise it; I did not put it into practice. I simply gave the idea, and a year or two after giving the idea, I lost confidence in thinking that it was the best way of doing it, or that it would be practically useful. It is partially used to this day, but not for transmitting to great distances.

I suppose you would agree that in making a useful invention you have first of all to conceive the idea, and look upon it as a hypothesis worth trying, and then put it to the test of experiment to see whether it would answer your expectations?—Yes.

As regards the present system as described in the specification, of distributing by means of a high tension alternating current with transformers across the main in parallel and with a secondary circuit, in which the lamps are arranged in multiple arc, you do not find any trace of that in any of the prior specifications?—I find that in Edison's specification. I find there that very idea, but with continuous current instead of alternating current.

Never mind whether Edison goes so near that anybody could have seen how to alter it; what I put to you is this: The system described is the having mains carrying a high tension alternating current, having transformers consisting simply of plain coils placed alternately on the mains, and distributing those by multiple arc. That idea was not known before?—I find that idea anticipated in every detail, except the idea of transforming down, although in those anticipations the inventors may have thought of transforming up.

You know the difficulty was then weight of copper, and that was to be solved by transforming from high tension into low tension somehow?—Yes.

And as a means of solving that difficulty, had anybody ever thought of a system of high tension alternating current mains with transformers consisting of simple coils, the secondaries of which were low tension mains, with lamps in multiple arc?—The apparatus for doing it is suggested by Brush, and Gaulard and Gibbs came so near to it with their multiple arc on central circuit that it was only necessary to straddle to secure the result. That was the only alteration—to put the primaries in multiple arc instead of series—necessary to make it effective.

To convert failure into success?—It was one of the ways of changing failure into success in Gaulard and Gibbs. All the invention required was that while the lamps in Gaulard and Gibbs were in parallel, they had also to put the primaries in parallel on the mains.

But I ask you, having regard to the increasing size of areas and the increasing weight of copper, which was the problem to be solved, if anybody—as a means of solving that problem—had conceived the idea of using the mains with a high tension alternating current, with transformers, with simple coils, and a secondary potential?—I do not know what was in the minds of other people; but it is certain that all the means of doing it, all the apparatus and the connections for doing it, were fully published before this specification. It would have occurred to me in an instant if I had seen the previous specifications and had been asked how would you carry out that object. Any person with Brush's specification or Gaulard and Gibbs before him would have seen it. You would only have had to change from one of the well known modes—series—to the other well known mode—parallel.

But the fact that people of practical experience missed the thing shows that it is not so obvious as you think?—I do not know how many people missed it.

In answer to Mr. Justice FARWELL, Lord KELVIN said he first saw the series system of primary transformers in use at the Grosvenor Gallery, and soon after—he thought in 1886—there came the change by Mr. Ferranti from series to parallel.

In further cross-examination, Lord KELVIN said that almost without exception practical electrical engineers at the date of this patent considered that the loss by keeping transformers always in connection would be great. Until Mr. Ferranti took the matter up almost everybody thought that it was not a practical or an economical system. A system of having a transformer in the house for every user was not approved of; but Mr. Ferranti saw that the use of a transformer for each house was practicable and absolutely essential.

Mr. Bousfield: Ferranti himself regarded the alteration from placing the transformers in series to placing them in parallel, as one of the most important improvements made in the apparatus?—A very important improvement, but also an improvement in the transformers; and I believe that that led to the initial partial success of the Grosvenor Gallery system. In the Gaulard and Gibbs case he (Lord Kelvin) said on May 22nd, 1882, that there was an important congregation of gentlemen connected with electricity who gave evidence before the Select Committee on the Electric Lighting Bill. Sir Wm. Siemens' idea and his own then was, that small areas of, say, a quarter of a mile, were the right thing for lighting towns. That, practically, would be the Edison system; and he (witness) then said that it might be dangerous to bring wires of high tension into houses at all. He first saw the application of induction coils in parallel at the Grosvenor Gallery in 1886, and he then saw how it could be applied to a town.

And so far from this alteration being obvious in 1886, even after this had been proposed, and Ferranti had seized upon the idea, there were many prominent electricians who still regarded this suggestion as an unpractical thing?—Yes.

Prof. Forbes, for instance?—Yes.

I have here an article by Prof. George Forbes in the *Electrician* of February 26th, 1886, on "Some Points of Electrical Distribution." He there discusses this very system of Zipernowsky and Déri, and comes to the conclusion that it was an unpractical system, and suggests another means of using the transformers instead of putting them in parallel. Does not that confirm the view that electricians even of the first order had had their minds attracted to this system but still found difficulty in regard to it?—No, I do not remember having read the article by Prof. Forbes. If Prof. Forbes had known what was stated in an article in the German journal *Electrotechnik*, he would not have written as he had done in the *Electrician*. Prof. Forbes might have known of Zipernowsky's patent; but if he had seen that article, he would have known better about it than he could know from the patent itself.

But in 1885, wherever we can find references to Zipernowsky's patent in the literature of the time, we can find many electricians of high repute who thought the system would not do; and before Ferranti took it up very few electricians thought it would do.—I do not know that that is so. Zipernowsky's article was in anticipation of his patent, and it described his experiments. The subject had been fully investigated before this patent.

In re-examination by Mr. Moulton, the Witness stated that the plaintiff's specification added nothing to the knowledge of the world as to the arrangement of the coils in parallel. He found nothing in the claim which had not been done before. The success of coils in parallel was due to the fact of the electromotive forces in the secondary being independent of the resistance. If that was so, current would increase as demanded. There was no evidence to show that Dr. Hopkinson did not know of this—parallel distribution was well known in 1885.

Now, when parallel distribution was known, was there any invention in proposing to do at 20 places what was done at one?—No.

Was there any invention in exciting the induction coil from the two poles in a consumer's house?—No.

And remembering Brush, was there anything novel in suggesting that you should draw from parallel mains by transformers in parallel?—No.

M. Emile Fesquet, examined by Mr. Fletcher Moulton, said he became acquainted with Mr. Gaulard in 1882, when he was working first on transformers. Witness was an electrical engineer, now carrying on business in Paris. When Mr. Gaulard came to him he was working for the Jablochkoff Company. Witness was at the Aquarium exhibition of 1883, when Mr. Gaulard had an exhibition there, showing distribution of electricity by transformers. It was worked at the exhibition, and witness helped to work it. There were two machines of four columns. The secondary wire was four times thicker than the primary, and each column was a separate induction column, and could be connected either in series or in parallel, and the lamps were put in parallel on the secondary wire. He had done it there himself both in series and in parallel. That was done many times every day, and was a common thing—common knowledge. They were quite familiar with induction coils, and knew what the tension would be on the secondary.

In cross-examination by Mr. Bousfield, Witness said he had made transformers for Gaulard and Gibbs in 1884.

Mr. Bousfield: Mr. Mordey found, with one transformer of Gaulard and Gibbs, that when you varied the total current in the lamps from 10 amperes to 27 amperes, the voltage in your lamp circuit fell by about 25 per cent.—Yes; and that would be bad in practice.

That would be due to the resistance being too high?—Yes; in the transformer.

And in the Gaulard and Gibbs' system, using transformers in series, no such effect would take place?—Yes, certainly; when you work transformers in series.

When you are working on a constant current system, instead of a constant potential system, the difference of resistance in the system is of small importance?—Of course.

But in the Zipernowsky system the question of relative resistance in the transformer is of great importance?—Yes, when you work in parallel.

Now, do you suggest that in any text-book of that time such a phenomenon had been pointed out?—I cannot say about the text-book, but I know that we all knew about it.

Mr. Bousfield (showing witness a copy of the Electrical Review): Is that a picture of what was shown at the Aquarium?—Yes. There are shown four columns, and there is a little switch at the base of the instrument. The purpose of that switch was to put a plug on the main line. The switch only affected the primaries. If they put it on the first point there would be one primary working; if on the second there would be two primaries, and so with the others, but not necessarily in series.

Then will you tell me what that switch is for, and what it did when you put it on the first, second, third, and fourth columns?—When you put it on the first, you put the first column on the circuit on the main line; and when you put it on the second column you put the second column on the main line. I do not say in series, because it might be in parallel or in series, but you must first switch with this switch in order to get them on the main line. You could put all the four columns on the main line by means of that switch. If you connected them on the top, one after the other, I can connect them in series; and by connecting them in another way I can put them in parallel. I know that the Gaulard and Gibbs' system was the series system, and that their purpose was to confine their energy to one very long wire, and give each customer a constant current.

In re-examination, Witness said he had coupled the primary and secondary wires in series many times. The machine shown at the Aquarium was capable, by its terminals, of being coupled up either in parallel or in series.

The Court then adjourned until Tuesday.

Seventh Day, Tuesday, January 30th.

Mr. Sebastian Z. de Ferranti, examined by Mr. Cripps, said he was an electrician and a manufacturer of electrical apparatus, his works being situated near Manchester. He was the inventor of dynamo machines, which were still largely used in electric lighting installations. He had had a great deal to do with the theory of electricity both as a practical manufacturer of electrical apparatus and as a practical electrician.

Mr. Cripps (reading from the specification): "Now the object of this invention is to make all individual points of consumption of electrical energy quite independent from one another, all necessary regulation being made by or at the generator of electricity." Was there anything novel in that when this specification was published?—I do not think there was anything novel in it.

Mr. Cripps's examination continued: Was there anything novel in getting the necessary regulation by or at the generator of electricity?

The Witness: There might be something novel in the details for making the voltage of the generator approximately constant.

It would have been given by any alternating machine?—Yes; these machines at that date gave approximately constant voltage—that is to say, within a small percentage.

The Witness, continuing, said that his own machines were very closely self-regulating, and you might put on lights to the full number, starting from one, and the pressure varied very little.

Mr. Cripps: I need not read the next words to you, because that is merely a form of grouping, but then it goes on "The apparatus for the actual utilisation of electricity as incandescent and arc lamps, electromotors, &c, are in all cases connected up in multiple arc in local secondary circuit." Was there anything new in that?—Nothing whatever.

Then he says "In this manner we have conductors distributing the primary (high tension) current in as many branch circuits as there are local centres, and any desirable number of secondary (low tension) circuits." Was there anything new in having the conductors distributing the primary high tension and in having the desirable number of low tension secondary circuits?—I can see nothing novel in that.

Now I want to particularly call your attention to the next passage, because something is said to turn upon it:—"Now the electromotive forces of the two coils of a transformer bear a constant ratio to one another." Was that known at the time the specification was published?—It was generally known by a great many people.

You knew it yourself?—I did.

Further examined, the Witness said that there was no novelty at this time in saying the internal resistance should be low on the secondary—the lighting circuit. A great many years before witness saw an apparatus of Gaulard and Gibbs at work on the Metropolitan Railway, in which it was evident that the secondaries had a very low resistance. They were made of copper of considerable section, and they must have had a low resistance. Another reason why they must have had a low resistance was because they would not have carried the current for doing the lighting without getting too hot unless their resistance had been very low. He considered it was quite certain that it was known at the time that the resistance of the secondaries should be low.

Mr. Cripps: Now looking to the claim, "In the application of induction coils or transformers for alternating electric currents." Was there anything new in that at this time?—No, that is the beginning of the statement, and there is nothing wonderful in that.

Then he says, "The arrangement of several stations of second order as branch circuits of the main line."—That is certainly not new.

Is there anything new in supplying to the main line as constant as possible?—It is only what he would get from any of the well-known forms of alternating machines.

Let me ask you generally, do you find, having carefully considered this specification and claim as an electrician, anything that is new or that requires invention as against the knowledge at the time?—I really cannot see any invention in it in any part.

Referring to Brush's fig. 9, Witness said that he saw no difference whatever between that fig. 9 with its arc lamp and the plaintiff's specification reading in an arc lamp. The witness went on to state that he was referring to some electric lighting at Brighton when there was a company there supplying arc lamps throughout the town. In most cases each shop had one or two or more arc lamps in a series circuit from what was known as a Brush 40 light machine. Many people preferred to have 10 incandescent lamps in place of

one arc lamp. They then took away the one arc light, substituted 10 incandescent lamps and provided apparatus, so that those lamps could be turned on or off. He believed that was in 1882. It certainly was not later than in 1883, because he made apparatus himself at Hammond's works, in Finsbury, in 1883, for carrying out that work.

Now take fig. 7 of Imray. That has to do with motors, has it not?—Yes.

Now I refer back to the plaintiff's specification and ask you to read in the word "electromotor."—Yes.

Is there anything in the plaintiff's specification indicating novelty of invention as regards the motor which you do not find in this fig. 7 of Imray?—There is no novelty in putting motors in parallel as shown in fig. 7; the actual difference there is that M is a primary generator of electricity in Imray's specification, and in the plaintiff's specification it would be replaced by a local centre, which would mean a transformer, presumably.

Do you find in Imray all that you find in the plaintiff's specification with regard to motors?

Mr. BOUSFIELD: Really I do not think my friend ought to put it that way.

Mr. CRIPPS: Does the passage I have read to you refer to the use of a current derived from an induction coil?—Clearly it does.

Fig. 7 of Imray's shows motors attached to the primaries?—Yes.

Mr. BOUSFIELD: Are there any secondaries in fig. 7; because you suggest it by mentioning primaries.

Mr. CRIPPS: No. (To witness.)—Your view as to common knowledge at that date is that there was nothing in adding the transformers and so having the secondary current as well as the primary?—That is so, and therefore everything that was in the specification was told in that fig. 7. As to Edison's specification, I agree with Lord Kelvin that it describes all that there is in the plaintiff's specification, and a good deal more besides—the method of producing the alternating current, and the method of collecting the alternating current, generating it, and using it. I think that that machine would work practically for distribution on a small scale. In fact, I have seen a model of it working very successfully on a small scale, and my experience with commutators or rectifiers satisfies me that it could be so worked. Commutators or transformers would work perfectly well under Edison's. (Shown the *Times* article regarding Fuller's discovery.) I find described in that article a system of distribution from alternating mains, using the transformer and then taking the secondary current, the transformers being in parallel. The only thing not described is, that it does not say that the transformers are to be of low internal resistance; otherwise it is a description of a complete parallel system.

Now I take you to Rankin Kennedy's article in the ELECTRICAL REVIEW, and to the last words of that article. He there says:—"In parallel arc, however, the secondary generator is a beautiful self-governing system of distribution; but what about the size of conductors for such a system?" Now, so far as the system or arrangement which we find in the plaintiff's specification was self-regulating or self-governing—upon which he relies—do you find that described by Rankin Kennedy?—Yes. He states it most clearly, and he understands its action fully. He says it is "a beautiful self-governing system of distribution," that is to say, it transformed in parallel, and was self-regulating.

Would it put the lamps in parallel, too?—Clearly, that follows from the article. In the article by Zipernowsky and Déri, I find an actual description of what is in the plaintiff's specification. That description could not be read in any other way. Even in regard to the point of low internal resistance, there was no invention in the plaintiff's specification. We had been doing it before.

Cross-examined by Mr. BOUSFIELD: You infer from Zipernowsky's article practically everything that is in the plaintiff's specification?—Yes.

You have it stated that the number of lamps could be altered without altering or diminishing the brilliancy of the remainder?—That shows that there was low resistance. I knew in 1883 that low resistance was essential.

Not for transformers?—For all electrical apparatus, and I had experience of transformers. In 1883 I supplied two of my dynamos to the First Avenue Hotel. The installation was two dynamos and about 1,000 lamps. With a few running the light was bright.

When the whole lot were running were they not like red-hot hairpins?—No, not at all; but there was a drop in brilliancy. We had an alternating current.

I put it to you that the main difficulty was that your dynamos were made with too much resistance in them?—No; they were made with as low resistance as reasonably could be. The dynamos were ultimately taken out and continuous current machines put in and storage batteries used. But that meant re-wiring the whole place.

Now, with regard to Rankin Kennedy, in your view there was no invention at all about the plaintiff's system?—Yes.

According to you, it was perfectly obvious to any electrician?—To any electrician thinking about it. In my view, Rankin Kennedy is an electrician.

He clearly stated where the Gaulard and Gibbs' system is defective?—Yes, and so he has evidently thought about it, and he even sees to some extent that the blocking action which is bad in Gaulard and Gibbs' system, would have a good effect in a parallel system, and he was evidently thinking of systems of electrical distribution.

And yet he comes to the conclusion, with all this knowledge in his mind, and with the knowledge that the blocking, which was bad, could be put to good account if put in parallel, that "These phenomena indicate a vast objection, or rather obstacle, in the way of the distribution of electric lights by secondary generators, because although the main current is beyond the reach of the hand, or of any instrument, it can be reduced to nothing, or increased to its maximum, without in any way interfering with the wires or coils conveying it." Was not that condemning secondary generators for the purpose of distributing electricity?—Yes; there was a certain distance to which he had not gone.

Then, in his last paragraph, Mr. Rankin Kennedy says: "In parallel arc, however, the secondary generator is a beautiful system of distribution; but what about the size of conductors for such a system? Prodigious!" So that I may state his view roughly thus: that the blocking effect in the Garland and Gibbs' system was condemned by him, and that although it might be useful in the parallel system, it was objectionable on other grounds?—It is hard to say exactly what was passing through the mind of Mr. Rankin Kennedy when he wrote the word "Prodigious," but I take it that what he was afraid of was the details of manufacture of transformers to take a very high tension within themselves. It was the working of the details, not the broad enunciation of a principle, but the method of carrying it into commercial use.

I put it to you that the specification shows that Brush was ignorant of the fact that the current would be blocked to a certain extent when lamps went out, and that the same current would go on passing?—I do not see that it does.

Can you point out anything in the specification to the contrary? I say everything points to that view?—He may have been partly wrong with regard to the description of fig. 8, but he was perfectly right with regard to fig. 9.

Assuming that he is substantially right and that the going out of a lamp does not materially affect the current passing through the coils, then the same effect would take place in fig. 9, and it would not materially affect the current passing through the coils?—Yes, I say, because he would be working outside the limits with the transformers. It is what is known as magnetic leakage of the transformers.

Re-examined by Mr. MOULTON: In your opinion does Brush's fig. 9 show any electrician of 1885 parallel distribution by induction in multiple arc?—Clearly it does. Furthermore, one Brush lamp would require enough current to work 10 incandescent lamps. That was known prior to 1885.

Further re-examined, the WITNESS said it was not true that the alternating apparatus which he put up at the First Avenue Hotel failed because the resistance was not low enough in his machine.

Mr. ELI COLLINS, the librarian of the Patent Office Library, gave formal evidence as to when certain publications were put in the library.

This evidence closing the defendants' case,

Mr. MOULTON proceeded to sum up the case on behalf of his clients. The learned counsel said he proposed to frame his speech simply for the purpose of assisting his Lordship in dealing with the mass of material now before him, by putting his case in the form of propositions. The first thing they had got to do with was to get the background of public knowledge on which the patent was to be considered. His first proposition was that at this date the parallel system of distribution giving at each consumer's premises a supply of electric energy at constant potential, to be drawn off in multiple arc, was perfectly well known, both of continuous and alternating currents. The learned counsel said that that proposition was not really contested. The Acts of Parliament spoke for themselves clearly about it. The next question he meant to put before his Lordship was that the transformer was known as a machine which multiplied up or down the tension of the primary. Although he could support that by evidence of the greatest possible weight from the witnesses called on behalf of the defendants, he would first of all read the evidence given by Mr. Swinburne on the point. This the learned counsel did. His third proposition was that the excitation of an induction coil by a machine for the purpose of utilising its secondary circuit was not novel. The learned counsel said that Edison actuated a coil by alternating current and used a secondary current. That was not contested. He then came to the article of Zipernowsky and Déri. Beyond question then the secondary was used and the primary was excited. Nobody doubted that. The consequence was that at these dates they had got primaries, being excited, and secondaries being used. Therefore, it was old to use an induction coil, excite the primary, and use the secondary for what purpose you wanted. If that was common when you used a machine to excite it, there was no novelty in using your poles to excite it. The plaintiff then said: "Oh! the lamps in the secondary were not in parallel." That was what it all came to. Was there any novelty in that? The learned counsel said that his fourth proposition was that putting machines in parallel on the secondary of an induction coil was not novel. Mr. Moulton read the evidence given on this point, and said that when once parallel distribution was admitted it was implied that you drew off in multiple arc—parallel distribution meant drawing off by "straddling." The learned counsel said he should like to deal very shortly with the plaintiff's attack on the alleged anticipations. These anticipations showed that lamps were put in parallel on the secondary of induction coils actuated perhaps by machines or by poles and parallel distribution, which he (counsel) said was exactly the same thing. He did not think that he had put before their Lordships anything which had been controverted. The plaintiff did not deny that there was parallel distribution in Brush. There was no objection to the completeness of Zipernowsky and Déri. The simple question was whether that was intelligible. He then came to Edison. He thought Lord Kelvin put it quite rightly when he said that Edison did all that the plaintiff did, and more. And all the criticisms were in the "more." The learned counsel then referred to the article in the *Times* about Fuller's system, and contended that that article showed the world plainly that he had adopted that system of distribution.

The hearing was again adjourned.

Eighth Day, Wednesday, January 31st.

Mr. Fletcher Moulton, Q.C., continuing his speech for the defence, said that in the defence of a patent case, it was a forensic necessity, very often, to deal in dilemmas. Dilemmas were excellent forensically; but, judicially, they were not. The Judge had to decide on the construction of a document, and he would submit what he considered to be the real construction of this specification. He would refer to the claim which it contained. The claim was:—"In the application of induction coils or transformers for alternating electric currents, the arrangement of several stations of second order as branch circuits of the main line, *i.e.*, connecting up the local centres with the main line in multiple arc, to which main line is supplied an alternating electric current of a tension as constant as possible, substantially as described and shown in the drawing." He (Mr. Fletcher Moulton) submitted that what that meant was this—that this claimant said: "I am not going to do what Gaulard and Gibbs did, and put my transformers in series. Put them in parallel." That, and that alone, was the claim. He would deal with the words "stations of second order." Those were exactly the same as Gaulard and Gibbs. But he would admit that this specification contemplated using them with lamps in parallel. He (Mr. Fletcher Moulton), however, doubted whether it was limited by that. He did not admit that it was. But it was admitted to be common knowledge of electricians that the tension in the secondary circuit was independent of resistance, and there was no question that people would put lamps in parallel on such a circuit; so that it would be the ordinary way of doing it, and therefore he need not trouble to enlarge upon that point. But what was meant by this claim was—stepping from Brush's fig. 8, which had been done by Gaulard and Gibbs, to Brush's fig 9, then already known. This specification commenced by saying what had substantially been done in Brush's fig. 8, and then the plaintiff gave wise advice about how to use fig. 9. But he claimed fig. 9, and that was his (Mr. Fletcher Moulton's) interpretation of the claim. The claim was purely arrangement of those coils in parallel, and that was known. There was nothing but arrangement of what was known. There were things, perhaps, in the specification which were not arrangement, but they were merely rules showing only the scope which the arrangement gave to the engineer. These were not limitations, they only gave assistance in using the arrangements, and there was not one word in the specification which limited the breadth of the claim, or which entitled the other side to say that they had not got to defend the whole system of putting the transformers in multiple arc and parallel circuit. The specification said, "The distinctive feature of our system of distribution is that each group of induction coils or transformers of the several stations of second order shall merely constitute branch circuits of the main line for the primary current, *i.e.*, the primary circuits of the several local centres, any one of these being taken as a whole, are connected in multiple arc." There the distinctive feature was that they put their primaries in multiple arc; but when one turned to the drawing accompanying the specification they found that it was nothing but an arrangement of existing known means. The mention of "low resistance" in the specification did not limit the claim; it could not limit the claim, because it was too vague. First of all, did this apply to the secondary and to the primary?

Mr. Bousfield: Yes.

Mr. Moulton: My learned friend says "yes." If your Lordship will look at the provisional specification, line 17, you will see "If only the interior resistance of the induced bobbins is proportionally low." That was the way in which it was expressed. It was put much more accurately in the provisional than it was in the complete specification. "The several places of consumption in the local circuits are independent from each other in consequence of their distribution as branch lines of the secondary circuit line, if only the interior resistance of the induced bobbins is proportionally small, and if the primary tension of the station does not change." That is my first remark as to whether it relates to the primary. The next thing I cannot help remarking is that this is a complete afterthought which is not unimportant in this connection when the question is how it was understood. I say that until they came into Court all this referred to nothing but the secondary, and I believe it does refer to the secondary. I say if it did apply to the secondary it is meaningless. The learned counsel continuing, said, Was it novel to say that the resistance in the secondary must be low? He (counsel) felt positively indignant at this point being raised by his learned friend, Mr. Bousfield. It was saying that the whole world was beholden to the plaintiff for telling it something that a boy ought to have learnt in the first six days of his study of electricity, and which was universally, and must have been universally applied, by everybody who was entrusted to make an installation at all. So elementary was it, that his learned friend deliberately taught it to the Court. What he meant was, that it was merely Ohm's law, as one had got to apply it when calculating the effect of every single arrangement of electrical circuits. He had now dealt with all the points raised in the specification, and he would just deal with some of the points outside the specification which Mr. Bousfield had brought up as skirmishes to protect his flank. One was as to back electromotive force. His Lordship had not heard him (Mr. Moulton) say a word about that. He had proved that it was common knowledge that the electromotive force in a secondary was independent of resistance. That fact was known—Mr. Bousfield had told his Lordship it was due to a back electromotive force, but he (Mr. Moulton) did not care what it was due to. The important thing was to know what would happen, and it was proved that current would increase as the demand for it increased in the secondary. It was now quite understood why that was. The only important thing was that it was so, and therefore he was not going to trouble his Lordship about back electromotive force at all. It was not at all relevant. The real relevant fact was that the current increased as you diminished the resistance, which was old. Then it was said that it was known that secondaries were self-regulating; but what had that got to do with the case? Mr. Ferranti knew all that the plaintiff did, and he (counsel) could not understand because a man improved a thing that therefore he did not know how good it was. The learned counsel then referred to the three-wire patent, which he said had nothing to do with the present case.

Mr. Moulton, in conclusion, said that he felt he had dealt with all the matters which had been raised in the case. Primarily, he thought it to be the real issue in the case that if you took the claim and read it and considered the interpretation which any man would put upon it as a document, he would deem it to be a claim for arrangement only, and that arrangement was known to be old. The claim was a broad one, and he submitted that the patent must be held to be invalid.

Mr. Bousfield then replied on the whole case on behalf of the plaintiff. He said that assuming he was wrong about there being any novel idea or discovery being imported by the patentees, and assuming that every principle was old, and that there was nothing more in the realm of scientific discovery to be done to make the combination, still he should be on firm ground, and he did not know that his case would be very different to what he had represented it to be. The way he should base his case, even taking the worst against himself, viz., that there were no scientific principles to be discovered, and that everything which had been done followed known principles of calculation, the putting the thing together, and applying for practical purposes constituted the invention. The learned counsel claimed to have made out the essential practical direction of low resistance, without which, he said, the system could not be made to work. He should endeavour to show his Lordship that the patentees had been the first to elucidate a vital point in the construction of a transformer on which the possibility of this system, as a system of distribution, absolutely depended. It did not matter one straw whether the principles involved in an invention were well known principles. In the law of patents it did not matter if the patentee took well-known principles and ideas and put them together and made his system practicable. Gaulard and Gibbs tried to solve this question for years, and never solved it. Edison had his mind on the problem of distribution, and failed to show a practical solution of the thing. The same thing could be said of Rankin Kennedy. Lord Kelvin never solved the problem until he saw the plaintiff's system at work.

The hearing was again adjourned.

On Thursday, Mr. Bousfield concluded his reply, and his Lordship reserved his judgment.

Messrs Turner & Sons *v.* Brinsmead.

In the Queen's Bench Division of the High Court of Justice on the 3rd inst., when the above action, which has been already reported in the Electrical Review, was mentioned before Mr. Justice Mathew,

His Lordship intimated that he had received the report of the Assessor.

Mr. J. Eldon Bankes, who appeared for the defendant, said the position appeared to be that if his client was entitled to reject the lift the question was one of damages. On the other hand, the evidence was that the defendant was not entitled to reject the lift, but that it was in some respects defective, and evidence would be required to show what amount would be required to make the lift according to contract.

Mr. Justice Mathew said Prof. Kennedy's report was not wholly favourable to either side, and he strongly advised the parties to settle the matter.

It was then decided that the case should stand over to enable the parties to come to some arrangement.

Pembroke Urban District Council *v.* Dublin Southern District Tramways Company.

Last week, before the Master of the Rolls at Dublin, the hearing of this action was specially listed for hearing. The action was taken to restrain the defendants from laying conduits, manholes, and other necessary works in connection with the construction of their electric tram service in any portion of the township save those approved of by the plaintiffs, a section of the works complained of having been already laid—prior to the institution of the action—an operation which necessitated the breaking up of the macadamised portions of the road to the right hand side of the paved tramway tracks from a point known as Dornden to Elm Park. The contention of the plaintiffs was that the works referred to should be laid in the space between the two lines of tramway. When the case came into Court, a week previously, an adjournment on the motion of the plaintiffs was applied for and obtained, and it was then stated that negotiations for an amicable settlement were pending. When the case was called last week, Mr. Jeffreys (instructed by Messrs. D. and T. Fitzgerald) for the plaintiffs, informed the Court that the anticipated settlement had been arrived at and a consent entered into between the parties.

E

CORRESPONDENCE.

Professional Amenities.

I have only just seen your last issue, it having been sent on to me here from my office in London.

Surely the moral and impartial young man whom you keep to write up certain engineers and to write down others has shown his hand too freely. Really, Sir, you must give him a severe scolding. You say (or he says) that I was informed by you you could not publish the correspondence between Mr. Hammond and myself without Mr. Hammond's permission. That is true—you did say so. But your article goes on to state that I requested you not to publish the correspondence because the matter was, and is, before the Council of the Institution of Electrical Engineers, and I explained to you it was, by my act, *sub judice*. You, Sir, agreed with that. Now you take upon yourself to publish, *against my expressed wish*, correspondence which you thought at first you could not publish without Mr. Hammond's leave. Really your young man should at all events *pretend* to be impartial. I will not comment on your gratuitous comments on a situation that is *sub judice*. But of course you ought to have expressed no opinion—no, not even to help a close and trusted friend.

F. Hastings Medhurst.

Buda-Pesth, *January 29th*, 1900.

[The writing up or writing down certain engineers we usually leave to the disputants themselves, a course which our readers will agree is all sufficient to show how well the traditions of Great George Street are kept up in these degenerate days. The above letter, for instance, is a charming example of professional dignity. Mr. Medhurst admits that we desired Mr. Hammond's permission before publishing the correspondence he was so anxious at the outset to see in our columns. He does not say, however, that previous to this he requested us to write up the whole subject with the object of showing the electrical world the regard which is paid to what used to be known as professional etiquette. We did write an article, but when we frankly informed Mr. Medhurst that our views did not coincide with his, he then asked us later in the day to publish only the correspondence and leave our readers to form their own opinions. As to Mr. Hammond's permission, that, said Mr. Medhurst, was not at all necessary, for the matter was no longer in the private stage, publicity having been given to the correspondence at Tonbridge Council meeting.

We did not agree with Mr. Medhurst that the placing of documents, already made public, before the Institution of Electrical Engineers rendered the matter *sub judice;* what we did say in a letter to that gentleman, was to the effect that we would deal with the subject from the local press report, and abstain from using the correspondence. To this we adhered, but when Mr. Robert Hammond requested us to place the whole of the facts before our readers—and he would have supplied us with the correspondence but for the fact that it was already in our possession—the situation was entirely altered, and we did what any reasonable beings would do. The remainder of Mr. Medhurst's delightfully refreshing and impulsive effusion, composed in truly *Rapsodie Hongroise* style, needs no comment.

We have received a letter from another writer on the subject of our leaderette of January 26th, but it is too personal. Moreover, we think that with the insertion of Mr. Medhurst's communication a painful subject may now well be brought to a close.—Eds. Elec. Rev.]

Inductor Alternators.

Universal practice does not necessarily make a thing right. If it is right in this case, it simply takes all meaning away from the term "inductor alternators." The original definition of the term inductor alternator seems to me much more sensible, that is, a machine with fixed exciting and armature coils, their interaction being dependent on the variation of the magnetic flux through the latter, brought about by the rotation of keepers or inductors, in such a way that the flux in the moving portion is reversed (as in Kingdon) or pulsates (as in Mordey's original inductor, and Pyke and Harris's and others). I am not surprised that such a precisian as Mr. Mordey should now use the term in such a loose sense, especially as he took such trouble in 1887 to specifically differentiate between the two types. He then alluded to "what is known as a pole armature arranged to be operated by a field magnet consisting of a central core or cylinder from which pole pieces projected, the magnetising winding might be wound on and rotate with the magnet, or might be supported by the armature, which consists of a number of coils placed on laminated masses of iron of any convenient shape." He directly afterwards described the inductor alternator correctly by mentioning the type that is distinguished by having the generating coils wound on the poles or polar projections, the rotating part being a suitably-formed iron mass which acts by varying the magnetic circuit, and which he terms a "keeper." He evidently then thought that the question of having the exciting coil fixed or revolving did not affect the type of the machine.

It is interesting to note the improvements which were made in the two types Mr. Mordey mentions, and which have given the machines the forms now generally adopted. Messrs. Pyke & Harris, by making their inductors of approximately equal breadth to the distance from centre to centre of contiguous pole pieces, allowed of the use of solid metal through the greater portion of inductor alternators.

Mr. Rankin Kennedy attained the same object for machines of the revolving field type by making the armature laminations a continuous ring sufficiently deep for the magnetic flux from adjacent revolving poles to spread into approximate uniform density before entering the solid iron portion of the magnetic circuit. He distinctly called his revolving field a multipolar electro-magnet with either a fixed or moving coil, the question of the attachment of the coil not altering the type of the machine in his mind.

In 1883 Alexander Klimenko showed his machine, where with fixed armature coils and fixed exciting coils, he described the machine as having a revolving electro-magnet.

Mr. William Main in his patent April, 1887, describes a revolving field magnet excited by a stationary coil, but says nothing about inductors.

I have given the above quotations from patents, as I think that all these descriptions, together with those given last week, must have been the result of much thought and careful wording on the part of their authors, and more likely to be correct than loose definitions given, perhaps, with only a moment's thought.

The final definition you give that an "inductor machine means one having no revolving copper" is quite out of court; it would include an ordinary continuous current dynamo with a drum armature wound with insulated iron wire, and having a cast-iron commutator, and would not include a Pyke & Harris inductor alternator, having the inductors mounted on a gun-metal carrier.

Percy Rosling.

P.S.—The enclosed tracings are copies of figures shown in various publications and patents.

[We regret that we received the above letter too late to be able to prepare the figures which accompanied it, illustrating the types of machine referred to.

With regard to the main question, we must differ from our correspondent. If universal practice does not make a thing right, it certainly makes some things *expedient*, as in this case, and we consider the definitions which we quoted in our last issue to be both simple and sufficient. As for the precise meaning attached to the word "inductor" in 1883 and 1887, we must confess to a lack of interest in the matter. What concerns us more is present-day practice.

We may, however, point out that the distinction drawn by our correspondent is only apparent. The original definition, as given in his letter, is perfectly correct in every way. Moreover, the armature coils of the Ganz alternators may be said with perfect truth to be wound on the field-magnet poles, and variations of the magnetic flux through them are produced by the moving mass of steel which forms the inductor. That this is so is easily proved; remove the inductor altogether, switch on the exciting current, and test the stator with a compass needle, or switch off the exciting current and observe the throw of a galvanometer in circuit with the armature winding. The results are quite consistent

with the view that the stator is the field magnet! The last paragraph of Mr. Rosling's letter calls for no comment.—Eds. Elec. Rev.]

Friction Losses in Dynamos.

On page 128 of your issue of January 26th, Mr. Hay writes that the notion that the friction loss varies directly as the pressure on the bearings is widespread but erroneous. Doubtless the two may not be always in direct proportion, but those who have made many experiments on the friction losses in dynamos will agree with the authors whom he cites, viz., Messrs. W. B. Esson and J. Fischer-Hinnen and Prof. F. G. Bailey, that any increase of pressure due to want of symmetry in the magnetic field of a dynamo usually does increase its bearing friction, and to a much greater degree than Mr. Hay would lead one to suppose. The reconciliation of this fact with the experiments of Mr. Tower and Prof. O. Reynolds' theory of friction is not, however, difficult. How far increase of pressure will increase the friction loss entirely depends on how it is applied. In the axle boxes, say, of a railway wagon, any increase in the load presses immediately on the axle within the bearings, and practically uniformly along the length of each journal. But in a dynamo, if the increased pressure is due to want of symmetry in the magnetic field, it is applied to the shaft midway between two bearings. The shaft, therefore, being held at the ends, must be more or less *bent*, and this affects the exact condition of the journals relatively to the bearing surfaces; in other words, the thickness of the film of oil upon which the friction loss depends. The whole question, therefore, as to how far the increased load will increase the friction turns entirely on the rigidity of the shaft, and the interesting experiment recorded by Dettmar with an eight-pole generator probably only shows that the shaft and core were very rigid, so that although the armature was pulled upwards or downwards by the unequally excited poles, the bending of the shaft was inappreciable. Thus it is hardly true to say that heating of the bearings in an excited dynamo which runs cool when not excited, *must* be due to bad workmanship or defective lubrication; it *may* be due to bad design, owing to which the shaft is not sufficiently stiff, or if the want of symmetry in the field is due to some abnormal condition, the shaft may be subjected to a stress for which it was not designed.

C. C. Hawkins.

Bedford, *February 3rd*, 1900.

The Use of Rubber Insulated Wires in Steel Conduit.

I notice in the "Correspondence" columns of your last issue, that under the above heading Mr. V. Zingler apparently questions the use of 300-megohm quality wire in steel armoured insulating conduit.

Whilst Mr. Zingler is welcome to retain his own ideas, it may be of general interest to point out that we have now had several years' experience with this grade of wire inside insulated conduit, and we are satisfied that such low quality wire is giving complete satisfaction.

Mr. Zingler may perhaps be "sorry" for me also, when I tell him that my experience has led me to conclude that *bare* copper wire installed in our insulated conduit is durable and satisfactory, and that as a consequence I have incurred considerable expense in working out (and patenting) the details of a complete system on such lines.

If my memory serves me well, in 1897 Mr. Zingler thought that in selecting a system, "climate, practice, and *national temperament*" had to be considered. I have been browbeaten by all three, and now venture to hope that the last, and in England, most difficult condition, is being overcome. Further, whereas Mr. Zingler was originally prepared to concede an extra value of 50 per cent. to an iron pipe system guaranteeing a smooth interior, he may be pleased to hear that at the present moment steel armoured insulating conduit is *just twice* the cost of ordinary gas-barrel, so that our then individual differences are gradually narrowing. With the growth of earthed outer wiring, I think we shall be able to offer Mr. Zingler a system 50 per cent. lower in price than his original gas-pipe ideal.

All of which goes to show that I believe in an electric wiring millennium!

Fred. Bathurst.

February 6th, 1900.

Having refreshed my memory by looking up my Review file, and being both interested and amused by the "cross fire" of the various discussions on wiring matters occurring under the above and similar headings, I would ask you to grant me space for the following remarks.

Whilst welcoming Mr. Zingler's contribution of January 5th under the above heading, as being in all ways a decided improvement on his contribution of May 7th, 14th, and 21st, 1897, it seems to me that he has advisedly modified his opinions even if he does not now directly contradict his previous remarks.

To quote from his own words in 1897: "He could not help thinking that uninsulated pipe (he would not call it 'bare') had not had a fair look in," and although he then looked upon prime cost "as an investment against depreciation," he seemed to wish to impress upon his readers that insulating lined pipes were as unnecessary as they were expensive. Certainly he said that chemical and electrolytic action was "a most important thing to avoid, because it was the father of all mischief," but apparently he was then satisfied that galvanising, or an inside and an outside coating of Angus Smith solution (which should not "peel off") made a plain iron pipe quite good enough.

In his earliest ideas he mentioned that exceedingly high insulation (of the conductors) is of less importance than insulation which will remain unaltered in the course of years, and stated that this quality was one "mainly discovered by experience," but now surely he is admitting that an uninsulated pipe system is not quite "so cheap in first cost and as durable in insulation" as he at first conceived? Within the short space of three years he states that "the imperishableness of vulcanised rubber in iron pipes is now recognised," and that this recognition is likely to become more marked in consequence of the largely increased use of steel conduits.

I note, further, that he thinks the forthcoming rules should specially distinguish "metallic" (or *conducting*) conduits, and the precautions which should be adopted when using them, and with this conclusion I am quite in accord.

Many probably enjoyed his distinction between "close" and "closed" tube, and saw for the first time how profit can be made upon a "shiny" bedstead tube, when the same can be bought as an untreated article at half the cost if purchased directly from the drawing mills. But surely when he admits that "enamel is no insulator, but merely a temporary, and not always homogeneous protection against rusting," he comes very near advocating the advantage of adopting a permanent and insulating lining.

May I suggest that a system worked out with the *untreated* article, would not only be "completely cheap," but might also be designated *simpl*-icity itself.

It is also a little difficult to reconcile his criticism of 1897—"that he is afraid an insulating pipe is only an encouragement to the jerry wirer to put in bad wires," with his present statement that the "putting in" (slinging?) of low insulation rubber-covered wires "is easily got over by a judicious and impartial system of inspection by the supply authorities."

Shortly, it seems to me that Mr. Zingler wants to be optimist and pessimist in one and the same breath, but I trust he will not consider my remarks "Very Singular," or as causing unnecessary heat, when I sign myself

M. E. Heaton.

Newport, *February 5th*, 1900.

I regret prolonging this correspondence, but shall be obliged if you will allow me to insert some quotations from Mr. Zingler's article, showing that my statement, contradicted by him, was not without foundation.

In making comparisons of cost, certain axioms must be granted, chief amongst which are:—That "only the best material and workmanship are employed." . . . . "But we must take the *absolute* standard."

"If we admit for the moment that we can put 300-megohm wire into insulated pipe."

He then proceeds to deal with the insulated pipe side of the question, entirely as used with 300-megohm wire, and further on we find: "And if the tube has half the insulation necessary (*i.e.*, 300 megohms), why should not the wire have the other half? Thus showing that 600-megohm is the *absolute* standard, in his opinion, for this piping.

I would remark that this is only one grade better quality than the 300-megohm class, and not much superior in actual work.

This closes the correspondence as far as I am concerned, and I only regret it has been so unduly extended.

W. H. Isherwood.

Re Glasgow Telephones.

With reference to the notice appearing under the above heading in your issue of 12th ult., I shall be glad if you will kindly insert the following corrections:—

In the paragraph referred to it is stated "The National Telephone Company uses wire weighing 12·54 lbs. to the mile for its underground cables," which is altogether misleading and incorrect. The weight of the wire used by the National Telephone Company in all its underground work is 20 lbs. to the mile, and of this class of wire it has laid down during the last few years approximately 150,000 miles. It is, however, right to say that a few experimental lengths of the lighter and cheaper wire have been tried by the National Telephone Company, with the result that its use has not been approved. For overhead cables the weight of the wire used is 20 lbs. per mile, and for general distribution work it is 40 lbs. to the mile, the same weight as the Postmaster-General's specification laid down for Glasgow. For junction lines erected overhead the wire in general use is 100 lbs. to the mile. These weights of copper wires have been habitually used for telephone works for many years in this and other countries.

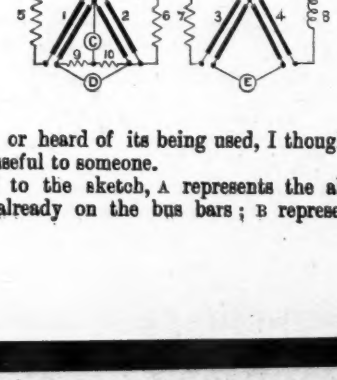
Dane Sinclair, *Engineer-in-chief,*
National Telephone Company, Ltd.

[The statement which is corrected in the above letter was not ours. We showed in our issue of January 12th, in the note referred to, that the Postmaster-General's specification for a municipal license had been submitted by the Glasgow committee to Mr. A. R. Bennett, "who takes exception to several of the clauses" . . . . "Mr. Bennett points out that the National Telephone Company uses wire weighing 12·54 lbs. to the mile for its underground cables." Possibly Mr. Bennett may be disposed to defend his statements, which are said by Mr. Sinclair to be "altogether misleading and incorrect."—Eds. Elec. Rev.]

Paralleling Single-Phase Alternators.

The accompanying method for detecting whether the incoming engine is going too fast or too slow when paralleling single-phase alternators occurred to me some 12 or 14 months ago.

Circumstances having brought it to my mind again, and not



having seen or heard of its being used, I thought it might perhaps be useful to someone.

Referring to the sketch, A represents the alternator or alternators already on the bus bars; B represents the incoming alternator, 1, 2, 3, and 4, are small transformers, 1, 2, and 3 preferably taking a large magnetising current, and 4 a small one; 5, 6, and 7 are non-inductive resistances, 8 is a choking coil; 9 and 10 are non-inductive resistances; C, D, and E, are incandescent lamps, and *b* a switch.

It would probably be advantageous to have resistances in series with lamps D and E, so that C, D, and E, could be lamps of equal voltage. The lamps should light up in the orders C, D, E or E, D, C, according to whether the incoming alternator is running too fast or too slow. It might be advantageous to replace 1 and 3 by one transformer, and perhaps wind all the batch on one set of cores.

Transformer 4 and choking coil 8 should be arranged to get as large a lag as possible, and perhaps condensers taking the place of resistances 5, 6, and 7, would improve the apparatus.

William Stansfield.

Moss Side, *February 3rd*, 1900.

Information Wanted.

Could you, or any of your readers through your columns, supply me with the name and address of any firm manufacturing or selling double or single cotton *insulated* soft charcoal iron wire, size about 18 to 20 B.W.G.? I have tried several wire manufacturers with no satisfactory results.

A Weekly Subscriber.

Sterilisation of Water by Ozone.

In my letter on the sterilisation of water by ozone (Electrical Review, January 26th last) I expressed some doubts about the adoption of the Marmier-Abraham system by the Lille municipality as stated by Mr. Kershaw.

Mr. J. Blondin, editor of the *Eclairage Electrique*, whom I asked if this statement of Mr. Kershaw's was correct, has just written me that he does not know anything about the adoption of this said system by the Lille municipality, and that it is impossible to obtain the slightest information, and that he was even complaining of the silence kept by the inventors on the question of cost.

E. Andreoli

BUSINESS NOTICES, &c.

American Plant for England.—The *New York Commercial* says that Mr. A. K. Baylor, recently manager of the railroad department of the British Thomson-Houston Company, who has been in the United States for the last two months, in the interests of the London United, Bristol, and Isle of Thanet Tramway Companies, has sailed for England by the American liner *St. Paul*. Before his departure, Mr. Baylor said to a representative of the paper mentioned:—

Of the $5,500,000 which it will cost the London, Bristol, and Isle of Thane Companies for equipment, certainly 90 per cent. will find its way into American pockets. During my stay here I have ordered equipment to the value of $250,000, which amount would have been ten-fold had I been able to get deliveries. I will return in about three months, when I hope to make further contracts.

In talking of the prospects of electric traction in England, Mr. Baylor said that the South African war had caused a complete stoppage of important deals like the Manchester, Liverpool, Leeds, and other large corporation work. The electrical schemes hung up involve about $50,000,000, and when they are put through fully $25,000,000 worth of material and equipment will be purchased in the United States.

Austria.—Large new works for the manufacture of calcium carbide are being established on the banks of the Upper Moldau near Krumau. Messrs. Ganz & Co., of Buda-Pesth, and the Berlin Electricitäts Gesellschaft are also interested in a scheme to establish works in Almissa for the production of aluminium, &c., by electrolytical methods.

Bankruptcy Proceedings.—An application for an order of discharge was made last Tuesday at the London Bankruptcy Court on behalf of Ernest Anthony Max Winter, electrical engineer, Amberley House, Norfolk Street, Strand. The Official Receiver reported that the bankrupt failed last October, with liabilities, £984 11s. 2d., and no assets. He came to this country from Berlin in 1889 with a free capital of £300. Four years later he entered the service of the Smithfield Market Electric Supply Company, and in May, 1897, he commenced to trade on his own account as an electrical engineer at Amberley House, adopting the style of the Imperial Electric Light and Power Company. The bankrupt had no practical knowledge of electricity, but paid a consulting engineer a retaining fee of £4 a month and a commission on the profits. His business consisted of obtaining concessions from public bodies and others for the supply of electricity, which concessions he proposed,

if and when obtained, to assign to a limited liability company that he intended to form. Only one such concession was obtained, and that was sold at a gross profit of £2,000. No company was floated, and although the bankrupt expended considerable time and money in the effort to obtain further concessions he was unsuccessful, with the result that in September last the landlord distrained on the office furniture. The bankrupt attributed his failure and insolvency to the heavy expenses of carrying on the business with but little return. The offences reported were (1) insufficiency of assets to pay 10s in the £ to the unsecured creditors; (2) imperfect books; and (3) contracting a debt provable in bankruptcy without having reasonable expectation of being able to pay it. The bankrupt did not dispute the findings of the Official Receiver, and Mr. Registrar Linklater imposed a suspension of two years.

On Wednesday a meeting of the creditors of Mr. Frederick King, electrical engineer, of Bristol, was held at the office of Mr. E. G. Clarke, the Official Receiver. The debtor was represented by Mr. W. H. Brown. The gross liabilities were £822 17s. 11d., and £502 17s. 11d. ranked as unsecured. There were no assets to meet this amount. It was explained by the Official Receiver that the receiving order in the matter had been made upon the petition of the debtor's late partner, with whom he carried on business from 1883 to January, 1897, as electrical engineers, &c. The cause of the insolvency was stated by the debtor as follows:—"Since the dissolution of partnership it has been found that my share had been overdrawn to the extent of £300 or £400, whereas I was always under the impression that I was worth at least £1,000." The only creditors scheduled were the debtor's solicitor and the partner referred to. The property at the debtor's residence was claimed by the wife. This claim the Official Receiver, who is acting as trustee, is investigating.

Liquidations, Dissolutions, &c.—A general meeting of the Direct Electric Generator ("Foreign Rights") Syndicate, Limited, is to be held on March 5th, at Montague House, 64, Gresham Street, E.C., to hear from the liquidator (Mr. Percy Mason) an account of the winding up. This will be followed by a similar meeting of the Direct Electric Generator Syndicate, Limited.

The Crowdus Accumulator Syndicate, Limited, has decided to wind up voluntarily. Mr. Claud Scott, of 32, Victoria Street, is liquidator.

A meeting of the Electrical Time Recording Company will be held at 31, Bedford Row, on Wednesday, March 7th, to hear an account of the winding up from the liquidator, Mr. A. B. Clifton.

Messrs. J. G. Moody and A. Hodgkiss (cycle manufacturers, electrical and general engineers, carrying on business as the Birkdale Cycle and Engineering Company, at Liverpool Road, Birkdale), have dissolved partnership. Mr. C. P. Greenwood, solicitor, 2, Post Office Avenue, Southport, will attend to debts.

Messrs. J. B. McMorine and G. E. Bryan (Mack, Bryan & Co., Old Haymarket, Liverpool, gas and electrical engineers), have dissolved partnership.

Calendar.—One of the handiest calendars we have received this year is that of Messrs. Sax, Slatter & Co., Ltd. A complete calendar for 1900 is printed in black on bright metal measuring 4 inches × 5 inches, and it is arranged with back support so that it may stand on the desk and be always conveniently to hand.

The Copper Markets in January.—The last issue of Messrs. H. R. Merton & Co.'s statistical reports on copper, shows that stocks have fallen by 1 490 tons during the past month, and that the price has advanced 25s. per ton. The total supplies during January have only amounted to 19,267 tons; the January shipments from America, from Spain and Portugal, and from Chili, all being disappointingly small. Shipments from Australia and from "other" countries are, however, above the average, and have helped to save the consumer from a more decided advance in price. The shipments of "Standard" copper to America from Liverpool and Swansea have amounted to 475 tons, bringing up the total since July 1st, 1899, to 10,363 tons. The exact figures for the month are as follows:—Supplies: America, 9,600 tons; Spain and Portugal, 1 924 tons; Chili, 1,600 tons; Australia, 2,200 tons; other countries, 3,943 tons; total, 19,267 tons. Deliveries: 20,282 tons. Stocks: December 31st, 1889, 22,817 tons; January 31st, 1900, 21,327 tons. Price, January 31st, 1900, £71 5s.

Electric Elevator.—At the new insurance buildings of the Ocean Accident and Guarantee Corporation at Glasgow, there is an electric elevator by the Sprague Electric Company. It is one of their fast travelling erections, with a rise of 175 feet per minute, and a car that accommodates 10 passengers.

Electric Power and Cold Storage.—Messrs. Handley and Shanks, of Dublin, write:—"We notice in last week's issue of the ELECTRICAL REVIEW an account of the electric power installed in a new ice making factory and cold storage at Birmingham, which it is claimed is the largest installation of its kind in the kingdom. In this, we think, your correspondent is wrong, as we ourselves about 12 months ago fitted up, for power and light, the whole of the works of the Cork Cold Storage and Ice Making Company. This firm uses motors for all purposes. The compressors, of which there are three, are driven respectively by 25 H.P. motors, whilst agitators, gantry, elevators, fans, and pumps are all actuated by independent motors. The aggregate of the power used is about 130 H.P., and we believe it represents the largest power installation at present in this country."

"Electric Tables."—Messrs. Whittaker & Co. will issue in June a new work by Mr. W. Perren Maycock with the above title. It will be a waistcoat pocket-book comprising 50 tables for electrical engineers, electric light fitters, &c.

Fire.—On Tuesday last week a fire broke out at the works of Messrs. Wenham & Waters, electrical engineers, of Croydon, and did considerable damage.

For Sale.—Among our small advertisements this week will be found an announcement to the effect that the business, plant, stock, &c., of Messrs. Cuttriss, Wallis & Co., Limited, electrical engineers, Leeds (in liquidation), is offered for sale as a going concern.

Nernst Lamp.—A company is reported to be in course of formation in Paris to acquire from the Allgemeine Electrici äts Gesellschaft, of Berlin, the French patent rights in the Nernst electric lamp.

Smoke Nuisance.—At Lambeth Police Court on 31st ult. Mr. S. H. Webster, secretary to the South London Electric Supply Corporation, Limited, of Bangeworth Road, Loughborough Junction, appeared before Mr. Hopkins, to answer a summons taken out by the Lambeth Vestry, who complained of the nuisance caused by the issuing of black smoke from the chimney shaft of the corporation's works. In addressing the Court for the defence, Mr. Wontner declared that the corporation had taken every possible precaution to avoid a nuisance, and called Mr. F. A. Nixon, engineer-in-chief to the corporation, who described in detail the methods which had been adopted to prevent smoke issuing from the shaft. In the course of the case for the defence, it was stated that owing to the present condition of the coal market, it was almost impossible to get coal of the character of that usually used at the works. A suggestion was also made that the vestry witnesses had mistaken coloured steam for smoke. In giving his decision, Mr. Hopkins said the nuisance would have to be stopped, or the works would have to be closed. He should impose a penalty of £10, and 2s. costs.

Trade Announcements.—The electrical engineering business formerly carried on by Messrs. Calvert & Co., of Manchester, has been taken over by Mr. J. Collier, lately assistant engineer with Messrs. Lacey, Clirehugh & Sillar, and is now being carried on under the style of John Collier & Co., at 4, St. Mary's Street, Manchester.

The British Electric Works Company, Limited, inform us that they have appointed the following agents for the sale of their specialities:—Mr. A. C. Hands, Garlick Hill, for London; Mr. S. Jevons, in Birmingham; and Messrs Gent & Co., in Leicester.

Messrs. O'Gorman & Cozens-Hardy state that their address after February 12th will be 82, Victoria Street, Westminster, S.W.

Wire Table.—We have received from Messrs. Johnson and Phillips a large framed card of particulars of copper conductors of over 90 different sizes. These are arranged in the common sense way, in order of their cross-sectional areas, and range from 22 S.W.G. (0 0006 square inch) to 91/11 S.W.G. (0 95 square inch). The current-carrying capacity is given both at 1,000 amperes per square inch, and on the scientific basis adopted by the Institution; the usual columns of dimensions, resistance and weight of various lengths are given, as well as columns showing the maximum resistance and the minimum weight permissible, these being respectively 2 per cent. over and under the normal values. The table is, in fact, based on the recommendations of the Committee on Copper Conductors, as these allowances would lead one to suppose, and may be relied upon as giving practically correct values, while its mode of mounting renders it very handy for reference.

ELECTRIC LIGHTING NOTES.

Accrington.—The Town Council has passed a resolution authorising application to be made to the Local Government Board for borrowing the sum of £63,647, for the erection of electricity works and plant, and other purposes. It has also been decided by the Council to oppose, along with other municipalities in Lancashire, the Lancashire Electric Power Bill which is to be promoted in Parliament during the present session.

Asylum Lighting.—The Committee of Visitors of the North Riding Lunatic Asylum have accepted the tender of Messrs. Crompton & Co., Limited, for lighting the asylum by electricity and the work will be carried on under the direction of Mr. A. A. Campbell Swinton, as consulting engineer.

Bombay.—*Indian Engineering* says that the Committee appointed to consider and report on the subject of electric lighting has decided to postpone its consideration until the Commissioner is able to obtain from such firms as desire to compete definite terms and proposals, after allowing them sufficient time for making surveys and collecting any necessary information.

Brighton.—The Town Council have taken the unpatriotic course of refusing to pay half the salary of one of the members of its electricity staff, Mr. C. C. Fowler, during his absence in South Africa with the Imperial Yeomanry. As the other members of the staff have volunteered to do Mr. Fowler's work, the Council is thus trading on his patriotism and that of the staff, and is making an unworthy profit "on behalf of the ratepayers."

The Council has resolved to offer to all electric wiring contractors in the borough to collect, on their behalf, during a period of seven years, the charges agreed upon by the occupiers of premises fitted on the hire system on stated terms.

Canterbury.—The municipal electricity works at Canterbury, the opening of which we had the pleasure of attending in March of last year, are not only giving an excellent supply, but are achieving results which for a small concern are remarkably gratifying. At the end of December last they had been in operation for just nine months, and the records for the period show a gross profit of £1,228, or a net profit, after paying interest on the loan and the instalment for the capital redemption, of £199, available for the reduction of the city rates. The figures are as under:—

Revenue for nine months	£2,099
Costs of generation and distribution	871
Gross profit	£1,228
nterest on repayment of loan	£1,029
Net surplus	£199

The number of Board of Trade units sold for the nine months was 98 177, so that the total costs of generation and distribution work out at the very satisfactory figure of 2 13d. per unit. At December 31st there were 7,557 lamps of 8-C.P. connected, while a further 1,079 awaited connection. For the initial operations these results reflect great credit alike upon Mr Robert Hammond, the Corporation's consulting engineer, and Mr. Staniland, the resident engineer. We look forward with interest to the publication of the accounts at March 31st for the complete year.

Cleckheaton.—Last week it was stated to the Council meeting that the Bradford Corporation, the North Bierley Gas Company, and the British Electric Traction Company had lodged formal objection to the granting of the Council's electric lighting order, with the object of securing clauses for their protection. It was resolved that the clauses suggested by the objectors could not be accepted, and that the Council's solicitor should take such steps as he should consider advisable for the purpose of resisting the claims put forth. The *Bradford Observer* says that in regard to the proposed light railways the solicitor to the Council attended with reference to correspondence he had had with the solicitor for the British Electric Traction Company, from which it appeared that the company were repudiating the undertaking of their agent, Mr. Paris, to the effect that the company would take electrical energy from the Council, and also seeking to withdraw from other promises. It was decided that such steps should be taken as might be deemed necessary for the purpose of procuring the performance by the Traction Company of their agent's undertaking to the Council.

Dublin.—The Dublin Electric Lighting Company's Bill came before the Examiner of Standing Orders last Thursday, when Mr. R. S. Badham appeared upon a memorial made by the Corporation against it. The Examiner held that in several instances the Bill did not comply with the standing orders. It will, therefore, have to go before the Standing Orders Committee of each House of Parliament before it can be taken further.

Gravesend.—The Tradesmen's Association has passed a resolution urging the speedy adoption of electric lighting in the town.

Halifax.—The Electricity Committee of the Town Council has decided, subject to the approval of the Council, to grant a bonus to members of the staff employed at the electricity works, on the total works and management costs, when these are brought below 1·5d. per unit. Last year the total cost per unit was 1·651. The Committee propose that for every one-tenth of a penny, and *pro rata* for every one-hundredth of a penny, a bonus of £130 be given to the staff in the following proportions:—To the chief engineer, £50; to the assistant engineer, £40; to each charge engineer (now numbering three), £10; and to each driver (at present four), £2 10s. It is suggested that the scheme be in operation for the two years ending March 31st, 1901, after which it shall be subject to revision. The electricity works now holding the lowest totals in Britain, the Committee states, are:—Edinburgh, 1·21; Nottingham, 1·36; Chester, 1·38; Bradford, 1·43; Southport, 1·45; and Leeds, 1·50. Assuming that the Halifax output should be 1,500,000 units, every one-tenth of a penny per unit on costs saved would mean a saving to the Corporation of £625.

Hendon.—At the last meeting of the Urban District Council, Mr. Robert Hammond was appointed consulting engineer to carry out the municipal electricity supply scheme, at his usual fee of 5 per cent. on the executed works.

Harrogate.—The Town Council has accepted various tenders for mason's work, ironwork, &c., in connection with the extensions to the electric lighting station.

Hull.—We give the following report of the proceedings which occurred at last week's Council meeting at some length because we consider the matter of considerable interest. The report is a somewhat lengthy abstract from the *Eastern Morning News* of 2nd inst.:—

Mr. Skinner rose to defend the action of the Electric Lighting Committee in accepting the tender of Messrs. Thomas Parker, Limited, of Wolverhampton, for two dynamos at a total cost of £5,035, in preference to that of Earle's Shipbuilding Company for £3,725. The task he had before him was a novel and an unusual one, but the Committee proposed an honest and the only efficient solution to the problem which they ventured to place before the Council, and which they hoped would be accepted. He had always, in his experience of contracts, contended that, all the circumstances being equal, the lowest tender should be accepted. But, whilst the practice was general, it was always thought advisable and practicable that when tenders were invited it was on the clear understanding that the lowest was not necessarily accepted. When the Sub-committee looked into the tenders received, they at once saw that with the figures which came before them there would be some little embarrassment. He did not want to make any remarks which would reflect on any individuals or any particular firm. He had the greatest possible regard for those who had control of such a great and important undertaking as Earle's Shipbuilding Company. But this dynamo was one of a type of which there were very few in the country. There were, he might say, a thousand dynamo makers in England (*sic*), but only a dozen who were recognised as capable of making the kind of dynamo they required. It was not merely a question of expert knowledge or a theoretical understanding of the science of electricity; but it was a question affecting the welfare and safety of a very large constituency. Messrs. Earle had not made any dynamos of the electrical power the Corporation required. He had received a circular from Messrs. Earle in reply to the statements which had been made as to their tender, and he understood that members of the Corporation, other than members of the Electric Lighting Committee, had also received copies.

Alderman Rollit: Is that so?

Several members of the Council said they had not.

Mr. Skinner said he understood they had been sent.

The Town Clerk, at the request of the Council, read Messrs. Earle's statement. The company admitted they had not made dynamos of so high an electrical pressure as were now required by the Corporation. That was also true, they might say, of some other makers of direct electrical machinery in the country. Messrs. Parker, Limited, made their first dynamo of this high pressure for the Wolverhampton Corporation, and their second for the Hull Corporation. Messrs. Parker, owing to the action of the Wolverhampton Corporation in giving them the order, had been enabled to create a large industry in that town. Therefore, Messrs. Earle asked the Council to do the same for Hull, and safeguarded them by offering to test the machine to twice the working pressure, against the one and a half times asked for by the city electrical engineer. They had made many successful dynamos and motors, the largest being a 48-inch armature dynamo, or only 12 inches less than the Hull Corporation; but Messrs. Parker had not made one of that size until the recent order of the Wolverhampton Corporation. Earle's had specially large plant and facilities for making dynamos of over 1,000 H.P., and the best insulating materials on the market were purchased. No electrical or other engineer could predict absolute immunity from breakdown; but the writers would do everything that a scientific staff, skilled workmen, and the finest machine tools in the country could accomplish. The city electrical engineer, as an expert, had every opportunity of criticising Earle's design, and of visiting their works as often as required, and of giving expert approval to every pennyworth of material built into the machines. They had, it was pointed out in conclusion, designed and made nearly 40 successful dynamos and motors of various sizes up to 250 KW., and had received "repeat" orders from the Admiralty, the Great Eastern Railway Company, the Dominion Atlantic Railway Company, and Empreza Nacional, Lisbon.

Mr. Skinner, resuming, adduced instances in support of his contention that it was not always the practice to accept the lowest tender. In work of that kind attention was paid rather to the class of workmanship. Mr. Skinner added that he had received a letter from the city electrical engineer giving reasons why he advised the Committee in favour of the acceptance of the Wolverhampton tender. Mr. Barnard wrote:—

> In the first place, I advise the Committee to pass over the lowest tender, on the ground that Messrs. Earle have no experience in the manufacture of large high tension dynamos, and very little experience in the manufacture of dynamos at all. I still feel very strongly that the Council will be taking a very serious risk of failure if they accept the tender of any firm, local or otherwise, who have so small an experience in this work, when I consider that it is absolutely necessary that these machines should be in thorough working order before Christmas. I do not pretend that the firm whose tender I recommend you to accept is the only firm who could do the work. There are many first-class dynamo makers who could do it, including all the others who submitted tenders on this occasion. Messrs. Earle cannot, however, claim to be first-class dynamo manufacturers as yet, for, though they say that they have made nearly 40 dynamos, I believe that these have all been small low tension machines, and even the one biggest machine that they claim to have made I believe is not yet finished, and has not, therefore, been proved to be successful. Messrs. Earle have also circulated a letter purporting to contain statements made by you and myself to them. Personally I disclaim responsibility for the statements there made, which I have no recollection of having made to any representative of Earle's Company. They are, in the main, arguments which I used in sub-committee, when no reporters were present, but there are several statements among them which I should certainly not have published, as I consider that it would be unfair to other firms involved to have done so. Again, in this morning's paper Messrs. Earle state that the largest dynamo they have made is considerably more than half the size of the dynamos required by the Corporation, and quote the relative diameters of the armatures in support of this. The diameter of the armature is, however, only one factor in determining the output of a dynamo, and, according to Mr. Willatt's statement to me, the machine in question, when finished, will only have an output of 200 KW., as against the 460 KW. specified for the Corporation machines. In conclusion, I regret exceedingly that I cannot recommend you to accept Messrs. Earle's tender, and so keep the work within the city, but I am satisfied in my own mind that it would be unwise to do so, and that in all probability the difference in the prices quoted would be more than outweighed by the advantages of placing the order with a firm who have proved by experience that they can make these machines as they ought to be made.

Mr. Millington seconded the resolution.

Mr. Porter moved, as an amendment, that the tender of Earle's Shipbuilding Company be accepted. Messrs. Earle had pledged their reputation as engineers, and that was sufficient for him, and he was satisfied if they placed the order with them, they would get as good a machine as could be built by anyone. He had consulted with experts, who told him that the company would be able to execute the work, or they would never have tendered for it. If the Corporation of Hull refused to entrust the work to Messrs. Earle, could they expect other Corporations to place work with them?

Mr. Feldman, in seconding the amendment, said that Mr. Skinner's knowledge of dynamos was about equal to his and other members

who had had no practical experience, and he did not think they need attach any importance to his technical arguments. He pointed out the important fact that Messrs. Earle had had contracts given them by the Government, and they had given satisfaction, but what would be the impression in the minds of the country and the Government if the Corporation of Hull were not willing to give them a contract for only £4,000? The electrical engineer, in his report, did not say the firm were incompetent nor incapable of doing the work. Mr. Skinner's remark that there were not men in Hull who could do the work was a reflection upon the working men of the city. The Corporation ought to have sympathy with a firm that had had a chequered career lately, not on account of their bad work, but rather on account of their too excellent work, and they ought to encourage them in a new industry which might be the means of employing a large number of people.

Mr. Panton regretted, as a member of the Electric Lighting Committee, that he felt compelled to oppose the minutes. He had the greatest respect for their chairman and for their engineer, but he opposed the latter's suggestion in committee as strongly as he could, and he was sure that if they accepted Messrs. Parker's tender they would be wasting an excessive amount of money, and, at the same time, doing an irreparable injury to one of the leading firms in Hull. He did not think it fair to assume in argument that if Messrs. Earle did the work it would be a failure. He thought the same disadvantage might be applied to the other firm.

Mr. Holder said Mr. Willatt, Earle's chief electrician, was a most experienced man, and he, of all the men in England, was selected some years ago to advise the Electric Lighting Committee on some purchases they were making. The engineer was all right as a station engineer, but he was not supreme. The man who could work an electric station easily could not make a dynamo. When Mr. Willatt said he could make a dynamo, he would sooner take his word than that of the engineer. The making of an efficient dynamo simply meant workmanship, enough copper, and proper insulation. Messrs. Earle would make dynamos that would run as well as Messrs. Parker's all over the world. If they gave the local firm the order they would create an industry that would be a credit to the city of Hull. There was a great chance to do a good thing for Hull, and they ought to seize it.

Mr. Skinner, in reply, referred to the difference in the experience of the two firms.

The amendment was carried by a large majority.

The following letter from Messrs Earle's Company was printed in the *Eastern Morning News* for February 1st:—

> At the meeting of the Hull Chamber of Trades on Tuesday night last Mr Councillor J. Brown is reported to have said, when asked why the Corporation Electric Light Committee had rejected Earle's Company's tender for dynamos, though the lowest, that Earle's had hitherto only made dynamos of half the size, and that not even the whole of the dynamos are executed by Earle's themselves. This statement is very misleading. The largest dynamo made by Earle's is considerably more than half the size of the dynamos required by the Hull Corporation, the largest dynamo made by Earle's having a 48-inch diameter armature. The Corporation's will be 60-inch diameter, and Earle's have special plant for making much larger ones than these. The dynamos are designed, the patterns made, and the dynamos machined and constructed at Earle's, but all the materials, rolled copper bars, insulating channels, &c., are purchased from other firms, as they are by all other makers of dynamos in this country; in fact, some of the principal dynamo makers have not even a foundry like Earle's, and get all their iron castings from outside people. Earle's specification allows for the completed machines to be tested to twice their working pressure, against the one and a half times asked for by the city electrical engineer. Moreover, the difficulties of construction and their remedies are known to electrical engineers to-day, and are well provided for by Earle's Company.
>
> Earle's Shipbuilding and Engineering Company, Limited.

Italy.—A concession has been granted to a Milan syndicate to utilise the water-power of the Rivers Ticino and Moesa in the generation of electrical energy for lighting and power purposes.

Lancaster.—At the Town Council last week Mr. Bowness protested against the Corporation granting £1 per week to Mr. Fraser, borough electrician, while on service with the Imperial Yeomanry in South Africa, but nobody supported him. A tender was accepted for a refuse destructor on which £14,700 will be spent.

Leeds.—A report on the electric lighting undertaking, prepared by Messrs. Hopkinson and Talbot, consulting electrical engineers to the Leeds Corporation, was issued last Friday to the members of the City Council. The present plant in the premises in Whitehall Road, they state, is capable of dealing with a maximum load of 3,000 KW. The maximum demand last year was 1,500 KW. In the coming year it will probably rise to 2,250 KW. "There is, therefore," the report continues, "ample margin of power in the plant now installed, and if domestic lighting only were contemplated, little capital expenditure would be necessary in the course of the next two or three years, except for cable extensions as need arises. The units sold in 1898 were 1,200,000, and it is probable that this year they will number about 1,800 000. When your present plant gets loaded up to its full working capacity of 3,000 KW. you should be selling current at the rate of 2,400,000 units per annum, if the same proportion continues to hold. . . . .

"On a sale of 2,400,000 units, therefore, you must charge 3¾d. per unit to pay your way. When the sales exceed this, you will have to increase your plant. The standing charges will then be increased, but not in proportion to the increased output, and a further reduction in price will be possible. Such reduction will, however, certainly be small, and in our opinion you may regard 3¼d. as the lowest average price at which you will be able to sell if you confine yourselves to domestic lighting. This price compares favourably with that charged in other cities.

"The intention is to expend the balance of £5,000 which is expected this year on the replacement of the defective rubber cables, the total cost of which will be, we understand, about £25,000."

On the question of the supply of electricity for power, Messrs. Hopkinson and Talbot state:—"Broadly speaking, the users of the power in a city like Leeds may be divided into two classes. Throughout the business districts of the city there will be places where motors could be used with advantage for such purposes as working hoists and fans, driving small tools, or printing machines, and for other light work. Motors such as these would be of small size, and they would be scattered over a considerable area compared with the total horse-power. On the other hand, there are certain districts—the manufacturing centres of the town—where power is used continuously and on a large scale for manufacturing purposes. In such a district the motors will be of much greater size, and large amounts of power will be concentrated on a small area. These districts are situated in the outer parts of the town. These two classes of demand, which may, perhaps, be called the domestic and the manufacturing, must be treated in different ways. To properly serve the first it is necessary to have mains capable of distributing power laid over a large area, so that the Corporation may be in a position to say to their customers that power can be supplied for light work, and to supply it without delay. The lighting mains, if of sufficient capacity, and if supplied with a type of current suitable for power distribution, may well be used for this purpose, for the motors would be for the most part so small as not to interfere with the efficiency of the lighting. But whether the lighting mains be used, or fresh distributors be laid, it may be said that the existence of a considerable distributing network is essential both to the creation of a demand for power for domestic purposes, and to the satisfactory supply of that demand. With manufacturers' power it is different. If a man decides upon working a factory, employing 20 H.P. and upwards electrically, it will in many cases pay the Corporation to lay him special mains for that purpose, and on the other hand, the delay attendant upon this procedure will not much matter to him. At the same time, such a factory could not well be worked from the lighting mains owing to the disturbance of the lights which might ensue. It should be noted in this connection that motors will, in general, cause more disturbance of the lights in an alternate current system, if worked off the lighting distributors, than in a continuous current system, other things being equal in the two cases.

"Looking first at the question of supplying what we have called domestic power, we may say at once that we believe a good deal can be done in this direction without any change in the present plant. There are several single-phase alternating current motors on the market which will do fairly well for any purpose in which it is not necessary to start on a load. They have certain disadvantages besides that of being unable to start loaded; inefficiency they are not equal either to polyphase motors or to continuous motors, and further, a comparatively small accidental overload will pull them up. Still in many cases these defects would not be very important, and we consider that in a field limited by its inability to start loaded, the single-phase motor can do all that is required. Broadly speaking, it may be said that where a fast and loose pulley can be used, the single-phase motor can do the work almost but not quite as well as the polyphase motor.

"We have considered in what way power can be distributed throughout the city for all purposes unlimited by the conditions which determine the field of operation of single-phase motors. Practically, two methods of doing this are available. The first, which is from an engineering point of view the most satisfactory, is to feed continuous instead of alternating currents into the existing distributors. The change, would, however, be so costly that we cannot recommend you to make it. We have found that an immediate capital expenditure of upwards of £50,000 would be required for the purpose.

"The question at issue is whether you should leave things as they are, contenting yourselves with extending as far as may be the use of single-phase motors; or whether you should change over to two-phase distribution. In the latter case you gain in being able to supply power for all purposes, including such as require the motor to start on a load, and the public gain to a precisely similar extent in the convenience of having such power at their disposal. Against this must be set an expenditure which we may say with certainty will be between £10,000 and £20,000, and the trouble and inconvenience attendant upon a change of system. The answer to the question must obviously depend on the number and size of machines in the city which cannot be properly driven by single-phase motors.

"The only objection which can be fairly urged against the two-phase alternating current system is that it is not satisfactory for the direct supply of arc lights. It will be necessary, therefore, if it is desired to light the streets by means of arc lights, to lay separate mains for the purpose, and to supply them with continuous current. This may be done either by means of rotary converters or by means of special arc machines driven by alternate current motors. The method to be selected would depend upon the number and distribution of the lights. It should be mentioned that in America it is common to have separate machinery and mains for the street arc lights even where a continuous current system of distributing mains is available, so that this disadvantage is not in practice felt to be of much importance. It certainly does not, in our opinion, outweigh the other advantages attendant upon employment of such currents in your case. Of course, for street lighting by glow lamps alternating currents are perfectly satisfactory."

Additional electric mains for lighting purposes are to be laid in the Burmantofts district at a cost of £4,600.

A deputation from the Corporations of Stalybridge, Hyde, Mossley, and Dukinfield, last Thursday, visited the Leeds electric lighting station in Whitehall Road, and the tramway electric generating station at Crown Point.

London—Lambeth.—The Highways Committee of the County Council, reporting upon the applications, of which notices have been given, to amend several electric lighting orders, stated that

the area of supply in Lambeth, where the order had been transferred, was small, including Westminster Bridge Road, and so much of the parish of Lambeth as lies north of that road. "We think it desirable," continued the Committee, "that, as the company to which the Vestry's order was transferred is now applying for an extension of its powers with regard to the remainder of the parish, the company should be placed under the same obligations, as regards the whole of the parish, as it would have been if the transferred order had been granted to it in the first instance. The order incorporates certain specified clauses of the Electric Lighting Clauses Act, 1899, instead of being in the form in which orders relative to London areas have been granted to companies, and Westminster Bridge should, following the usual practice as to bridges, be specifically excluded from the area of supply." It was recommended that the Board of Trade be asked to so amend the Lambeth (part of) Electric Supply Order, applied for by the South London Electric Supply Corporation, as to place the company under the same obligations, as regards the area included in that order, as though the order had in the first instance been granted to the company itself. This was agreed to.

NEWINGTON VESTRY.—The Electric Lighting Committee last week presented a very satisfactory report, and submitted a return to prove that all doubts as to the success of the undertaking had now been removed, and that the deferred system for the repayment of capital, as approved by Her Majesty's Treasury, would enable the Vestry by the end of 1902 to provide such a sinking fund out of profits towards the maintenance of machinery and the station as would ensure the ratepayers from ever being called upon to contribute towards its support. The Committee recommended: "That a circular letter be addressed to the consumers, thanking them for the support they have accorded to the Vestry's electric lighting undertaking, and explaining that, with the additional plant decided to be provided for the station rendered necessary by such support, the Vestry will by Michaelmas next be enabled to meet an increased demand upon the station during next winter, equivalent to 11,000 8-c.p. lamps." In proof of the great development of the undertaking, it was mentioned that in the June quarter of last year the customers' accounts amounted to only £36 16s. 2d., whereas they amounted for the last quarter to £1,126 11s. 9d. The motion was agreed to.

DEPTFORD.—At a meeting of the Committee of consumers appointed to consider the best means of obtaining redress in the matter of the electric light supply in Deptford, on Thursday last week, it was resolved to send a letter to the County Council, detailing the alleged irregularities of supply, and calling upon the Council to take steps in the matter. A similar request has been made to the Greenwich Board of Works.

ISLINGTON.—The County Council last week consented to the raising of loans of £38,000 and £10,000 by the Vestry, out of £56,261 and £13,200 for which its sanction was requested, complained that the Vestry has not supplied full particulars of the works contemplated. The Vestry resolved to ask the Finance Committee of the County Council to receive a deputation from the Finance and Electricity Committees of the Vestry in order to settle the matter.

LIMEHOUSE.—The Works Committee reported to the District Board of Works on a clause which the Thames Conservancy wished to have inserted in the Board's electric lighting order, for the protection of the rights and privileges of the Conservators. The Board consented to the insertion of the clause referred to. The Committee also reported that the clerk laid before them a statement of objections which the County of London and Brush Provincial Electric Lighting Company, Limited, had made to the Board of Trade against the grant of an electric lighting order to the Board; and it was recommended that the Board direct as follows, viz.:—(*a*) That a letter be addressed to the chairman of the Whitechapel District Board asking him to convene an early meeting of the conference upon the subject; (*b*) that the Vestries of Mile End Old Town and St. George-in-the-East be asked if similar objections have been made to their applications; (*c*) that the Board's Parliamentary agents be asked to inform the Board of Trade that the reply to the objections will be forwarded as early as possible. The recommendations were approved of.

MARYLEBONE.—As an outcome of the recent deputation to the President of the Board of Trade, respecting the irregularity of the service in Marylebone by the Metropolitan Electric Supply Company, proposals are before the Vestry to the effect that notice be given to all parties concerned that the local vestry intends to apply for a provisional order for generating and supplying electricity to the inhabits of the district, and that the necessary steps should be taken to invoke the aid of the Board of Trade with a view of bringing about an immediate reduction of the "exorbitant prices" charged by the Metropolitan Electric Supply Company for current in this parish.

SHOREDITCH.—The Finance Committee at a meeting of the Vestry on Tuesday reported having reconsidered the question of providing the initial capital expenditure in connection with the proposed extension of the lighting system to the Haggerston district. On the recommendation of the Committee, it was decided to make application to the London County Council for sanction to a loan of £32,095 for buildings and £63,905 for machinery and plant, making a total of £96,000, which was the amount of the estimate of the consulting engineers. Mr. Mansfield Robinson, clerk to the Vestry, reminded the authority that the Parliamentary Committee had sought to organise opposition to the Bill promoted by the County of London and Brush Provincial Electric Lighting Company to authorise the laying of mains through different districts so as to connect together the company's generating stations. Since then the Battersea Vestry had forwarded an invitation for two representatives to attend a conference of local authorities to consider the question of taking united action in regard to the company's Bill. Under the circumstances the Parliamentary Committee thought the Vestry should appoint representatives, and it was decided that Mr. N. Moss and Mr. J. G. Clark should represent the authority at the conference. The Lighting Committee reported that they had been requested to lay mains through the Canal Road, and they recommended that the work should be carried out at an estimated cost of £900. The recommendation was adopted. Mr. N. Moss, chairman of the Lighting Committee, informed the Vestry that success had attended the well-sinking operations, and that the well had been sunk to a depth of 362 feet. After a week's trial the output of water was found to be 6,000 gallons per hour, which was the maximum guaranteed by the contractors, and since then that hourly quantity had been exceeded.

BERMONDSEY.—The Vestry on Monday resolved to present a petition against the Bill promoted by the County of London and Brush Provincial Electric Lighting Company to authorise the company to link up its generating stations by mains laid through intervening districts.

Gloucester.—Mr. T. Duesbury, of Clerkenwell, has been appointed assistant engineer at the electricity supply works.

Ludlow.—At the monthly meeting of the Ludlow Town Council on the 1st inst., it was resolved upon the recommendation of the Electric Lighting Committee to call in Mr. Enright, of Westminster, to confer with the committee on the question of an electric lighting scheme for the borough.

Malton.—The District Council is desirous of imposing conditions upon the Northern Counties Electric Supply Association, increasing the compulsory area of supply and reducing the maximum charge, to which the association declines to accede. The Council has decided to ask the Board of Trade to enforce its request.

Malvern.—The District Council has been advised by Mr. R. Hammond to carry out an electric lighting scheme at an initial cost of £30,000. Mr. Hammond lectured on the subject at Malvern last week.

Manchester.—A failure of the electricity supply occurred on Monday, lasting from 5.30 p.m. to 6.30 p.m.

Margam.—The Urban Council will hold a special meeting on Monday to discuss whether to oppose the scheme of the South Wales Electrical Power Distribution Company.

Musselburgh.—At a special meeting of the Town Council on the 31st ult. an agreement was signed with the promoters of the proposed electric light and traction schemes for the burgh. The town will have the option of purchasing the system as a going concern at the end of 14, 21, or 28 years. An arrangement was made so that the electric lighting and tramway schemes can be taken over by the town at the same time. A resolution was adopted approving of the schemes.

Newport (Mon.).—A special meeting of the Town Council has been convened for the 13th inst. to consider whether to petition against the Bill of the South Wales Electrical Power Distribution Company. A meeting of the Monmouthshire County Council has also been convened, the same business figuring on the agenda.

Northumberland County Asylum.—The Finance Committee of the County Council recently recommended that application be made to the Local Government Board for power to borrow £8,500 for the electric lighting of the Asylum. The report was adopted by the Council.

Ogmore Valley.—The Board of Trade has renewed the Ogmore Valley Electric Lighting License, 1892, for a period of one year from September 16th last.

Oswestry.—The Local Government Board has refused the application of the Town Council for sanction to borrow £18,000 for the purchase of the undertaking of the Oswestry Electric Light and Power Company, Limited.

Ross.—The District Council last week decided to give its consent to the Ross Electric Light and Power Company, Limited, to be promoted by Mr. J. Parker, of Hereford, city surveyor.

Switzerland.—The "Motor" Gesellschaft, of Baden, Switzerland, is projecting a scheme to utilise the water-power of the River Aare, near Döttingen, in the generation of electrical energy. It is estimated that 10,000 H.P. will be available.

Walker.—The District Council has received a report of its Committee on the Bills promoted by the Newcastle-upon-Tyne Electric Supply Company and the Tyneside Electric Power Company, to the effect that terms can be arranged with one of the above companies which will be beneficial to the Council, and that a sub-committee has been appointed to consider the matter.

Worcester.—It has been reported to the City Council that a clear profit of £90 has resulted from the supply of electricity in 1899. The Council is to be congratulated on this long-hoped-for success.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Berlin.—The Berlin correspondent of the *Standard* says that a memorandum on the extent to which physical experiments are affected by the working of electric tram lines has just been laid

before the Reichstag. It was compiled in the Imperial Institute for Physico-Technical Experiments, and is to the following effect:—

The apprehension that magnetic and electrical operations would be disturbed by the electricity borne on overhead wires has, unfortunately, proved to be well founded. The first signs of such disturbances were evident directly this mode of locomotion was started on the circular railway, though this was 4 kilometres from the Institute. As the overhead wire system was extended, and the nearer it approached, the more marked became the disturbing effect. It can safely be said that, without the protective measures which the managers of the Institute had to take for its immediate surroundings, the use of the magnetic needle would have become next to an impossibility.

The *Standard* representative writes that "It might be worth considering whether it would not be advisable to remove an institution of the kind to some spot far from all trams and railways. At present, out of regard to the position of the Potsdam Observatory, electric traction is not adopted on the Wannsee line. The time will surely come when such considerations will not be allowed to interfere with public traffic. Probably it will be left to scientific men to devise a means of averting disturbing influences of the kind referred to in the memorandum. It is to be hoped that they will succeed, or the interests of scientific institutions may ultimately be overridden by the convenience of the public."

Hull.—The Corporation has arranged with the Electric Railway and Tramway Carriage Works Company to convert five trailers into motor cars. It is stated that the cost will be £300 per car.

Manchester and Liverpool Railway.—The Parliamentary estimates for the construction of the proposed Manchester and Liverpool electric express railway place the total cost of the scheme at £1,750,000. The estimates give the length of the railway from Deansgate, Manchester, to its termination at the Blue Coat Hospital, Liverpool, as just over 34 miles. The railway throughout will be constructed as a double line. The principal items in the estimates are—stations, £67,600; land and buildings required to be taken (310 acres), £451,600; permanent way, £18,000 per mile, £621,450; viaducts, £175,300, and contingencies, £117,940. The scheme is proposed to be carried out by a company with a share capital of £2,000,000, and a loan capital of £666,000.

South Staffordshire.—At a meeting of the Wednesbury Town Council on Monday the General Purposes Committee reported that they had received a communication from the Board of Trade on the electrically-equipped portion of the South Staffordshire tramways, and that the report was of a satisfactory nature. The Board intimated that they had renewed the use of electrical traction for a further period of four years without prejudice to the rights of the Wednesbury Corporation under the Tramways Act, 1870.

Wirral and Mersey Railways.—At a special meeting of the shareholders of the Wirral Railway Company held at Chester on Monday, it was resolved that the shareholders approve of the Bills to work the Wirral and Mersey Railways by electricity.

TELEGRAPH AND TELEPHONE NOTES.

Bournemouth Telephones.—The Corporation wishes to join with the Association of Municipal Corporations in a consideration of the question of establishing a municipal telephone service.

Edinburgh Telephones.—At last week's Council meeting the town clerk said that the Lord Provost and he had signed a telephone agreement that morning. One clause had been added to the effect that in the case of the Government taking over the telephones before the end of the period of 1911 the clause about their taking over the apparatus did not hold. They were not going to compete with the Government.

Glasgow Telephones.—At last week's meeting of the Corporation of Glasgow the Telephone Committee gave an account of their work, and submitted recommendations preparatory to the establishment of a municipal system of telephonic communication. The committee were able to state that they had secured a satisfactory adjustment of the terms of a license from the Postmaster-General, and they recommended that the license as now adjusted should be accepted by the Corporation. They also recommended that the Corporation should authorise them, in consultation with their expert adviser, Mr. Bennett, to prepare and submit for consideration a scheme, with the necessary estimates, for carrying the license into effect. The recommendations were unanimously adopted. The *North British Daily Mail* considers that the Postmaster-General lays down stringent conditions for the maintenance of his authority and the protection of his privileges. The license will run from February, 1900, till the end of 1913, and the area of the Corporation system will be co-extensive with that of the National Telephone Company.

Imperial Telegraphic Communication.—At last week's monthly meeting of the Liverpool Chamber of Commerce it was reported that copies of the resolutions passed at the meeting held on December 11th, when Sir E. A. Sassoon, Bart., M.P., addressed the Chamber on the subject of Imperial telegraphic communication, had been sent to members of the Cabinet, members of Parliament for Lancashire and Cheshire, and all the Chambers of Commerce of the United Kingdom. Acknowledgments had been received from the Cabinet, promises of support from many of the members of Parliament communicated with, and promises of co-operation from the following chambers, viz., Leeds, Huddersfield, Halifax, Birmingham, Wolverhampton, Leicester, Bristol, Newport, Plymouth, Dundee, Middlesbrough, Batley, Walsall, and Kidderminster. The London Chamber suggested that the matter should be brought forward at the Congress of Chambers of the Empire, and the Hull Chamber suggested that it might be discussed at the meeting of the Associated Chambers in March. Consideration of resolutions was promised by the Manchester, Glasgow, Cardiff, Dudley, and Bury Chambers.

The Pacific Cable.—In the House of Commons last week Mr. Hogan asked the Secretary for the Colonies whether he was aware that the dilatory proceedings of the Pacific Cable Board had occasioned considerable disappointment and dissatisfaction in the Colonies concerned, and whether he could state the position in which this important Imperial undertaking now stood. Mr. Chamberlain replied that the Pacific Cable Committee had held two meetings, and was making inquiries with a view to the settlement of a definite scheme. Those inquiries, relating as they did to technical questions, necessarily took time, but he had no doubt that there would be no avoidable delay. Mr. Hogan also asked whether certain concessions had recently been granted to the Eastern Telegraph Company as regards the opening of independent offices in the Australian capitals in connection with their proposed new cable from South Africa to Australia, and whether there was any ground for the apprehension that these concessions would seriously affect the financial success of the cable that was about to be laid from Canada to Australia under the auspices of the Imperial, Canadian, and Australian Governments. Mr. Chamberlain replied that the application of the Eastern Telegraph Company was, he understood, under consideration of the Australian Premiers at their conference last week, but he had not yet been informed whether they had arrived at a decision. The bearing of the application on the prospects of the Pacific cable would, no doubt, have been carefully considered by them.

The *Outlook* has the following:—"We are glad to learn on undoubted authority that the difficulties foreshadowed in some London journals as likely to arise between certain Australian Governments and the Pacific Cable Board have been removed—had, indeed, been removed before any published statement appeared. The Eastern Telegraph Company endeavoured, as it was bound in the interests of its shareholders to do, to secure from the Australian Governments privileges as regards the transit of messages overland in Australia which must have militated against the success of the Pacific cable enterprise; but the Australian Governments having fully accepted the principle of a cable jointly owned and maintained by the contributing States will, we may be sure, be parties to no proposals designed to delay and minimise the success of this joint enterprise. We are glad, also, to be assured that the members of the Pacific Cable Board are now one and all animated by a desire to push forward the project with all possible speed. It cannot come too soon."

The South African Telegraph Service.—Last week, in referring to the interruption of the East Coast of Africa cable between Mozambique and Lourenço Marquez, we quoted a notice which had been circulated through the press (about the end of January) to the effect that the East Coast cable had been repaired on January 12th, and that due notice was given of this by the International Bureau of Berne on the 13th. This press notice purported to be made on the authority of the Eastern Telegraph Company, and last week we questioned its accuracy, as in the official Berne journal of January 25th this cable is described as being still interrupted. In the Berne circular dated 1st inst. a notice appears to the effect that the cable in question, interrupted on December 17th, was repaired on January 12th *and* 26th. From this it would appear that there has been another breakdown on this line, subsequent to the 12th, of which the Bureau at Berne was not aware. Whether this be so or not, it is clear that some failure to report has existed, either on the part of the Eastern and South African Telegraph Company, or on the part of the Bureau International of Berne.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
West Indies:—		
Jamaica-Colon	June 30, 1899 ...	...
Trinidad-Demerara (1891 duplicate)	Oct. 23, 1899 ...	...
Cayenne-Pinheiro	Oct. 11, 1899 ...	...
Latakia-Cyprus	June 20, 1899 ...	...
Tarifa-Tangier	Jan. 2, 1900 ...	...
Landlines.		
West Indies:—		
Communication with Les Cayes (Haiti)	Nov. 21, 1899 ...	...
South African:—		
Communication with Mafeking and beyond	Oct. 13, 1899 ...	...
Communication with all offices beyond Orange River	Oct. 18, 1899 ...	...
Communication with north of Mooi River (Natal)	Oct. 22, 1899 ...	...
Communication with Colombia ...	Oct. 23, 1899 ...	...
Communication with Valentia (Venezuela)	Nov. 18, 1899 ...	...
Communication with all towns of United States of Colombia beyond Buenaventura	Jan. 22, 1900 ...	...
Saigon-Bangkok	Jan. 25, 1900 ...	Feb. 2, 1900
,, ...	Feb. 7, 1900 ...	...
Serena-Valparaiso	Jan. 16, 1900 ...	...
Rome-Pera	Feb. 2, 1900 ...	Feb. 4, 1900

Telegram Censorship.—In the House of Commons last week Mr. Lloyd Morgan, on behalf of Mr. Bainbridge, asked the Secretary to the Treasury, as representing the Postmaster-General, whether any censorship was exercised with regard to such outgoing telegrams from England to Africa as might be likely, directly or indirectly, to carry information to the enemy. Mr. Hanbury, in reply, said:—Under Article 8 of the International Telegraph Convention each Government reserves to itself the power to suspend wholly or in part the service of international telegraphs upon condition that it immediately advises each of the other Governments' party to the Convention. Notices have been issued under this article suspending code or cipher telegrams and applying the censure to other telegrams from or to Zanzibar, Seychelles, Mauritius, Madagascar, British East Africa, German East Africa, Mozambique, Delagoa Bay, Rhodesia, British Central Africa, Orange Free State, Transvaal, Cape Colony, and Natal. All such telegrams have to pass the censor either at Aden or at Cape Town.

Telephone Communication in Switzerland.—The Swiss Government is furnishing a guarantee in connection with the projected Lugano-Zurich and Bellinzona-Lucerne telephone lines. Work on the erection of the same will shortly be started.

The Telephone Service.—The National Telephone Company, Limited, has issued the following notice to its London subscribers *re* last week's snowstorm:—

The company regrets to have to inform its metropolitan subscribers that the snowstorm of yesterday has caused a partial dislocation of the London Telephone Service. No effort is being spared to get the service restored, but as it will take some little time before this can be fully accomplished, the company trusts that its subscribers will accord to it as much forbearance as possible. During the past four years the company has been using its utmost endeavours, but without success, to induce the London County Council to consent to the wires being put underground. Had the County Council done so the present trouble would not have occurred.

Tunbridge Wells Telephones.—At Wednesday's meeting of the Town Council the following scheme for municipal telephones, the area to be extended to serve several Kent and Sussex villages, was brought up in the report of the Telephone Committee, which was as follows:—

The Telephone Committee beg to report that they have carefully considered the subject of the establishment of a competitive telephone service, and that the result of the canvass which has been made for subscribers to such a service has been very satisfactory, and proves the need of a competitive service at a lower tariff than that charged by the National Telephone Company. The Committee, therefore, recommend the Council to proceed at once with the application for a license to the Postmaster-General, and to make the following suggestions to him:—(1) That such license should be for 25 years; (2) that the area to be served by the Council be the whole of the National Telephone Company's local area, together with the parishes of Withyham, Mayfield, Ticehurst, Goudhurst, Horsmonden and so much of the parishes of Brenchley, Lamberhurst, Wadhurst, Frant, Rotherfield, and Speldhurst, as are not included in the National Telephone Company's local area; (3) that the maximum charge for telephone service be as follows: Tariff No. 1, an annual payment (in advance) of £5 17s. 6d. to cover an unlimited number of calls. Tariff No. 2, an annual payment (in advance) of £3 10s., with a toll of ½d. per call payable quarterly or half-yearly, 1,140 ½d. calls (about 3½ per working day) would mean a payment of £3 10s. + £2 7s. 6d. = £5 17s. 6d., the same as under tariff No. 1. Calls in excess of 1,140 in the year to be charged ½d. each. Tariff No. 3, an annual payment (in advance) of £2 10s., with a toll of 1d. per call payable quarterly or half-yearly. 810 1d. calls (about 2½ per working day) would mean a payment of £2 10s. + £3 7s. 6d. = £5 17s. 6d., the same as under tariff No. 1. Calls in excess of 810 in the year to be charged ½d. each. The above rates to cover lines up to one mile in actual length from the nearest switch-room. Any excess distance over the mile to be charged at 10s. per annum per quarter mile or fraction thereof, no addition being made to the toll charges. The Committee also recommend the Council to authorise them to proceed in anticipation of the grant of the license, and to obtain specifications and tenders for the necessary works, the Committee laying the same before the Council in due course.

CONTRACTS OPEN AND CLOSED.

OPEN.

Aberdeen.—February 28th. The Tramways Committee wants tenders for four electrically-equipped tramcars. See our "Official Notices" this week.

Bath.—February 12th. The Corporation invites tenders for high and low tension cables, arc lamps and posts, transformers, and sub-station and main works' switchboards. See "Official Notices" January 19th.

Birkenhead.—March 1st. The Corporation wants tenders for the supply and laying of feeder and distributing mains. See "Official Notices" to-day.

Bootle.—February 17th. The Corporation wants tenders for underground electric cables. See "Official Notices" January 26th.

Coatbridge.—The Town Council is anxious to receive proposals from companies willing to lay down electric tramways. See "Official Notices" January 26th.

Durban (Natal).—April 2nd. The Corporation is inviting tenders for 1,900 tons of steel girder rails, 64 tons of fishplates (bolts, bonds, &c.), 407 loads Australian hardwood stringers, &c, also the laying of same for 14·36 miles of single track, and bonding 2·96 miles of equivalent existing single track, the Corporation laying concrete foundations and making up roadway. See "Official Notices" to-day.

France.—February 15th. Tenders are being invited, until February 15th, by the French Minister of Posts and Telegraphs in Paris for the supply of 585,230 metres of electric cables (paper insulated) in 12 lots. Tenders to be sent to Le Sous-Secretariat d'Etat des Postes et des Telegraphes, 103, Rue de Grenelle, Paris, whence particulars may be obtained.

Germany.—February 23rd. Tenders are being invited until February 23rd by the Königliche Wasserbau-Inspection, at Emden (to whom they are to be addressed), for the supply of nine 3-ton electrical cranes. The specification may be obtained, on payment of 2s., from Herr van Jindelt, the Königlichen Bau-Secretär.

Glasgow.—February 17th. The Corporation is inviting tenders for the following:—(1) 200—300 motor car trucks; (2) 200—300 motors and equipments; (3) the supply, delivery, and erection complete of the overhead trolley constructional work required for the equipment of the system. Specifications, with form of tender, &c., and all other information, can be obtained on application to Mr. John Young, general manager, 88, Renfield Street, Glasgow. A bank draft for £5 5s., payable to the general manager, must be sent along with application for specification for each item. Deposits will be returned on receipt of a *bonâ fide* tender. Sealed tenders, marked "Tramways, Tender for ——," must be lodged with the Town Clerk, City Chambers, Glasgow, by February 17th.

Gloucester.—February 27th. The Corporation invites tenders for the wiring of the Guildhall, public baths and electricity works, also the necessary fittings. See "Official Notices" to-day.

Great Yarmouth.—February 15th. The Corporation wants tenders for two water-tube boilers and three 200-kw. continuous current steam dynamos. See "Official Notices" Jan. 19th.

Hammersmith.—February 14th. The Vestry is inviting tenders for electrical stores for 12 months from March 25th. See "Official Notices" to-day.

Hastings.—February 12th. The Corporation wants tenders for 12 20-kw. alternating current transformers and sub-station switch gear. See "Official Notices" January 26th.

Horsham.—March 1st. The Urban District Council is wanting tenders for water-tube boilers, pipework, two steam dynamos, batteries, switchboard, 6-ton overhead traveller, mains, road work, enclosed arcs, and station lighting. See "Official Notices" January 26th.

Hull.—February 19th. The Corporation wants tenders for 35 double motor equipments and 10 car bodies. See "Official Notices" January 26th.

Leyton.—February 14th. The Electric Lighting Committee wants tenders for a switchboard for the new electric light works. See "Official Notices" January 19th.

Melbourne.—March 1st. The Corporation is wanting tenders for boilers, engines, dynamos, switchboard, feeders, mains, arc light leads, accumulators, &c., for electric lighting. See "Official Notices" December 22nd.

Newcastle-on-Tyne.—February 22nd. The Tramways Committee wants tenders for copper bonds. See "Official Notices" to-day.

Newcastle-on-Tyne.—March 2nd. The Tramways Committee wants tenders for 130 car bodies, trucks, and electrical equipment for same. See "Official Notices" February 2nd.

Newington.—February 20th. The Vestry wants tenders for two water-tube boilers, feed pump and extensions to steam and water mains at the electricity works. See "Official Notices" February 2nd.

Rochdale.—February 28th. The Corporation wants tenders for electricity meters. See "Official Notices" February 2nd.

Salford.—February 28th. The Corporation wants tenders for electrically-driven mechanical stokers, economisers, jet condensers, and pumps, with steam exhaust and water pipes, electrically-driven feed pumps, feed pipes, and travelling crane for their new electricity works. See "Official Notices" to-day.

Stockholm.—February 15th. Tenders are invited by the Administration of Swedish Telegraphs, for the supply of 300,000 kilogrammes of 4·5 mm. copper wire, and 190,000 kilogrammes of 3·0 mm. copper wire. Some particulars may be examined on personal application at the Commercial Department of the Foreign Office between 11 a.m. and 5 p.m.

Stoke-upon-Trent.—February 13th. The Guardians want tenders for the electric lighting of a portion of the workhouse premises. See "Official Notices" January 19th.

Sunderland.—The Corporation wants tenders for a tramways switchboard. See "Official Notices" January 12th.

Sunderland.—March 2nd. The Corporation wants tenders for the supply of steam, exhaust, feed and other pipes, and two steam-driven induced draught fans and accessories. See "Official Notices" to-day.

Walthamstow.—February 23rd. The District Council wants tenders for the supply of electric lighting and Dowson gas plant at the Isolation Hospital, Chingford. See "Official Notices" February 2nd.

York.—The Corporation invites tenders for the conversion of the wiring of the Courts of Justice to suit higher voltage. See "Official Notices" January 26th.

CLOSED.

Bradford.—The Corporation Tramways Committee, on 5th inst., decided to recommend the City Council to accept the tender of Messrs. Macartney, McElroy & Co., Limited, for the electrical overhead equipment of the Listerhills, Stanningley, Whetley Hill, and Thornton tramway sections, for the total sum of £12,064 15s. 2d. The Bradford and Shelf Tramway Company, Limited, has accepted the Corporation's offer for the acquisition of the company's unexpired leases and their property and plant.

London.—The Shoreditch Vestry on Tuesday considered the undermentioned tenders for the supply of sundry cables required to complete the laying of connections to consumers' premises:—

W. T. Henley & Co., Limited (accepted)	£899 6 1
W. T. Glover & Co., Limited	922 19 0
British Insulated Wire Company, Limited	924 6 7

Newcastle-on-Tyne.—The *Contract Journal* says that the contract for the supply of (*a*) 2,000 H.P. generator, and (*b*) two smaller generators, for the Tramways Committee of the City Council has been given to British Westinghouse Motor Company; (*a*) £16,000 (*b*) £16,450.

Sheffield.—Tasker's Engineering Company is to supply a jet condenser and piping extensions at the electric light works for £1,732

Tunbridge Wells.—The following is a list of tenders received by the Corporation Electricity Committee for a 400-KW. steam alternator:—

The Electric Construction Company (E.C.C. and Willans) ..	£4,615
Ferranti (Ferranti and Willans)	4,677
Ferranti (Ferranti and Ferranti)	4,820
Frank Suter (Willans)	4,827
General Electric Company (Oerlikon and Willans)	4,884
Crompton & Co. (Crompton and Willans)	4,896
Brush Company (Raworth and Brush)	5,810
Parsons, turbo-alternator	4,375
FOR CONDENSING PLANT.	
W. H. Allen & Co.	£4,505
Do. if with centrifugal pump	3,855
Wheeler Condensing Company	4,471
Klein Engineering Company	4,621
Worthington & Co.	4,975
Do. their own pump	4,647
Do. or the Baths scheme	4,167
FOR TWO LANCASHIRE BOILERS.	
Messrs. Tinkers, Limited	£3,060
Messrs. E. Danks	3,070
Messrs. Yates & Thom	3,296
Messrs. Musgrave & Sons	3,413

FORTHCOMING EVENTS.

Friday, February 9th.—At 5 p.m. Physical Society. Annual general meeting. Address by the President, Prof. O. J. Lodge, D.Sc., F.R.S.

Saturday, February 10th.—The Institution of Electrical Engineers. Students' visit to Messrs. Siemens, Bros. & Co's Works, Woolwich. Train leaves Charing Cross for Charlton at 9.20 a.m.

Tuesday, February 13th.—At 8 p.m. The Institution of Civil Engineers. After other papers have been discussed, one on "Corrosion of Marine Boilers," will be read by John Dawrance, M.I.C.E.

Wednesday, February 14th.—At 7.30 p.m. Institution of Electrical Engineers. Students' Meeting. Discussion on "Wireless Telegraphy."

Thursday, February 15th.—At 8 p.m. Chemical Society. Among other papers one will be read on "Note on the Refraction and Magnetic Rotation of Hexamethylene," by S. Young, D.Sc., F.R.S., and Emily C. Fortey, B.Sc.

Friday, February 16th.—At 7 p.m. Northern Society of Electrical Engineers. Annual dinner at the Grand Hotel, Manchester, Mr. Ferranti presiding.

Saturday, February 17th.—At 11 a.m. Institution of Electrical Engineers. Students' visit to Davies Street station of the Westminster Electric Supply Company.

Tuesday, February 27th.—At 8 p.m. Northern Society of Electrical Engineers, Grand Hotel, Manchester. Annual general meeting, presidential address, &c.

Wednesday, February 28th.—At 8 p.m. Society of Arts. Prof. Carus-Wilson on "The Electrical Induction Motor on Mountain Railways."

Saturday, March 3rd.—At 3 o'clock. Royal Institution. Lord Rayleigh delivers the first of a course of six lectures on "Polarised Light."

Tuesday, March 20th.—At 4.30 p.m. Society of Arts (Foreign and Colonial Section). Sir Edward A. Sassoon, Bart., M.P., "Imperial Telegraph Communication."

NOTES.

The Cannes Tramways.—Mr. Killingworth Hedges, M.I.C.E., sends us the following:—"Electric traction is being rapidly extended to almost all the principal winter resorts of the Riviera. The first section of the tramways at Cannes was opened about a year ago, but the enterprise has only just been completed, the single line now extending from La Zocca (the western suburb) to the town of Antibes (at the eastern end), a distance with the branches to the villages of Cannet and Vallauris of about 13¼ miles. The overhead work is of the usual type; the rails are laid in the middle of the very narrow streets, in fact, at the crossing places or turn-outs the line monopolises almost the whole width of the road, and would not have been sanctioned either in England or Germany. The position of the Tramway Company is certainly to be envied; not only has it obtained a concession without having to pay any annual contribution to the town, but it has so well met the want of the populace that in order to give more facilities to the private carriage owners, who naturally object to have to wait at times until the cars are able to pass, a project is on foot to continue the carriage road along the sea shore for the whole distance of the tramways, so that the cycling and motor car fraternity, who are in great evidence, can by a slight diversion from the ordinary road, hurry along at the racing speed which seems in France to be inseparable from amateurs 'on wheels.' The generating station is situated in the town of Cannes, and consists of three horizontal compound condensing engines, by Weyher & Richmond, of Pantin, Paris, driving three dynamos by belting of the Société Alsatienne des Constructions d'Electricité, Belfort, France, the E.M.F. on the distant portions of the trolley line being maintained by 'sur excitateurs'—Anglice, 'boosters.' The arrangements for condensing appear to be well worth notice. The water from the condenser flows into a tank, from whence it passes through a series of shallow troughs to remove the oil; it is then lifted and caused to meet a series of sprays of cold water and at the same time a current of air from the louvre work frames, which enclose the pipes. This condenser is known as the 'See.' The cars were constructed at the Chantiers de la Zeuve, Lyon, and are each fitted with two Thomson-Houston motors, which with the controllers, are the only portions of the outfit not of French manufacture. The peculiarity of French cars is mainly in the distribution of the seats. At each end there is an overhanging platform for the second class, four of whom can sit down, while 15 are allowed to stand. In the middle portion is the first class, the fares being double those of the second, the result being that the former is nearly always empty, while the platforms of the second are uncomfortably crowded.—Cannes, *February 2nd.*"

A Question of Tenders.—We refer our readers to a discussion (in our "Electric Lighting Notes" to-day) which took place last week at the Hull Town Council with reference to the tenders for dynamos for the electricity works. We are inclined to agree with the leader writer of a Hull paper, that "a dispassionate examination of the considerations urged in favour of overruling the advice of the electrical engineer and of placing the contract with Messrs. Earle & Co, tends to the conclusion that the Corporation has been animated by a natural desire to stretch a point in favour of a local firm, rather than to decide the case upon its own merits."

"Not a Bit of Difference."—We give our smart contemporary the *Financial Times* full credit for the following note:—"Metropolitan subscribers are informed by the National Telephone Company that the snowstorm has caused 'a partial dislocation of the London telephone service.' We have not observed any difference."

Appointments Vacant.—The Portsmouth Electric Lighting Committee wants a third assistant engineer at £100 per annum for the electricity works. See "Official Notices" to-day.

A shift engineer is wanted for the Halifax electricity works, and an assistant permanent way engineer for the Manchester tramways. See "Official Notices" this week.

Departure of Electrical Engineer Volunteers for South Africa.—Mr. W. G. McMillan, hon. sec. to the Dinner Committee, is sending out circulars calling attention to the proposed "send-off" dinner in London to the South African contingent of the Electrical Engineers (R E) Volunteers. He states that particulars as to place and date cannot be definitely fixed until the War Office shall have announced the date of departure, but it is expected to be about the end of February. Meanwhile, it has been decided to invite members of all classes of the Institution of Electrical Engineers, who care to do so, to become hosts on the occasion of the dinner, each host subscribing two pounds (£2), which will be devoted to defraying the expense of the dinner, both of the hosts and of the members of the volunteer contingent, the balance, if any, to be applied to some fund connected with the corps. Those who desire to become hosts are asked to send, before February 20th, a remittance of £2 to the honorary treasurer, Mr. Henry Elmunds, 2, Queen Anne's Gate, London, S.W., and also state whether they desire to be present at the dinner. We are asked to state that it is not intended to confine the dinner to members of the Institution. On the contrary, it is believed that there are many engineers not on the Institution member-roll who would be glad to avail themselves of this opportunity of showing their sympathy with the movement. They are cordially invited to take part. It is hoped that Lord Kelvin will be in the chair at the dinner.

We read in the *Times* that Captain F. L. Lloyd, Royal Engineers, chief instructor at the Plymouth School of Submarine Mining, has been selected to go out to South Africa in charge of the detachment of the Corps of Electrical Engineers accepted for service, which will be joined later on by Major R. E. B. Crompton, commandant of the corps. Major G. A. Carr, Royal Engineers, instructor in electricity at the School of Military Engineering, has been directed to give assistance to the committee which is purchasing plant for the detachment.

Lectures.—Mr. Wm. Lynd delivered one of his popular lectures at Elvaston on 2nd inst. His subject was "The Wonderful Century of Electricity." The lecture, according to published reports, dealt mainly with the Dowsing radiant heat and light cure, for which 25 branches have been opened in the leading health resorts in the kingdom.

At the Catholic University, Dublin, on 30th ult., the Right Rev. Monsignor Molloy, D.Sc., gave the first of a series of two lectures on "Electric Waves and their Application to Wireless Telegraphy."

On Monday, before the Royal Society of Edinburgh, a number of communications were made, the first being given by Dr. John Gibson on "A Thermostal, Electrically Heated and Regulated." The other topics dealt with included "The Law of Elastic Fatigue," "Magnetic Screening," "The Clark Cell *versus* the Cadmium Cell as a Standard of Electromotive Force."

At the Carpenters' Hall on Thursday evening, March 1st, a lecture on "Electric Light Stations" is to be delivered by Mr. C. Stanley Peach, F.R.I.B.A. Prof. A. B. W. Kennedy will preside. This is one of a series of free lectures connected with building which has been arranged by the Worshipful Company of Carpenters.

At the Edinburgh Philosophical Institution on 30th ult. Mr. Richard Kerr, F.G.S., gave a lecture on "Wireless Telegraphy."

At the St. James's Congregational Mission Church, Newcastle, on 30th ult., the third of a course of five lectures on "The Electric Current," was given by Mr. F. Broadbent.

A course of ten University Extension Lectures on "Electric Power and Lighting" is being delivered by Mr. E. Halford Strange, M.Sc., at the Town Hall, Hammersmith. The first lecture was delivered on Wednesday, January 24th, at 8.30 p.m.

Personal.—On Friday last Mr. R. A. Dawbarn, the late superintending engineer of the Brush Electrical Engineering Company, Limited, met the officials of that company at their London offices, and was presented with a token of esteem and goodwill, subscribed for jointly at Falcon Works and the London office, on the occasion of his leaving to join the ranks of the consulting engineers. The presentation, which took the form of a silver salver, a pair of silver candlesticks, and an illuminated volume containing the names of the subscribers, was of a very handsome character, and should be a pleasing momento to Mr. Dawbarn of his long association with the company. The presentation was made in happy terms by Mr. R. Percy Sellon, and suitably acknowledged by Mr. Dawbarn.

Mr. Haydn T. Harrison has joined the Electric Tested Lamp Company, of 15, Victoria Street, S.W., and is now their chief engineer and superintendent of the general testing and inspecting department which is being added to their business.

Correspondence.—As we go to press the British Insulated Wire Company writes:—"Our attention has been drawn to a paragraph, dealing with the Aberdeen electric tramways, in your issue of January 19th, in which it was stated that a breakdown of the service occurred, due to the failure of an underground feeder. The feeder cables referred to are of our manufacture, and were laid by ourselves, and we find that the cause of the trouble was due to a defect in the overhead equipment. We shall be glad if you will contradict the above statement in your next issue."

Responsibility of Engineers.—At last the long-promised investigation into the recent breakdowns at Cardiff has been carried out, with the result that Mr. Applebee, the electrical engineer, voluntarily accepted full responsibility for them, and was given complete control of all the employés without exception. Mr. Applebee has now a free hand, and we are confident that, before the expiration of the six months' trial of the new arrangement which has been allotted to him, he will put the affairs of the undertaking in thorough order. Further details of the investigation will appear in our next issue.

Fox v. The National Telephone Company.—This case was down for hearing on Wednesday in the Chancery Division before Mr. Justice Farwell, but before the action was called on, counsel stated that a compromise had been arrived at, and all he asked the Court to do was to make an order for the taxation of costs. The agreed terms involved the payment by the defendant of the plaintiff's taxed costs. All further proceedings would be stayed except for the purpose of carrying out the agreement arrived at. His Lordship made an order as asked.

Comparative Cost of Caulking by Hand and by Pneumatic Tools.—In the January number of the *Engineering Times*, a comparison is given of the comparative cost of caulking by hand and by pneumatic tools. Although the figures given are not vouched for, there is reason to believe that they are substantially correct, as they are received from a firm of good standing. In any case, unless the figures are very far wide of the mark indeed, they afford an inducement to boiler makers to give the pneumatic caulking hammer at least a trial. In an establishment where 18 men were employed to caulk, the wages bill at 34s. per week would be £1,595. One pneumatic tool is stated from actual experience to do the work of six men. Hence, three pneumatic tools would be required to represent the work of 18 men. The first cost of the necessary air compressor, receiver, and three pneumatic tools and connections, is stated to be £150. The cost is then worked out as follows:—

Interest on first cost (£150) at 10 per cent. ...	£15	0	0
8 B.H.P. required to work three tools, say, 50 tons of coal at 10s.	25	0	0
Wages of three men at 34s. per week	265	0	0
Wear and tear	25	0	0
	£330	0	0

Showing a saving of £1,595 — £330, or £1,265 per annum. Of course, coal is not everywhere obtainable at 10s. per ton, but on the other hand, the allowance of six tons per B.H.P. per annum is ample, and would allow of an inferior quality of coal being used. The allowance for wear and tear may or may not be sufficient, but in any event the saving works out to a remarkable figure.

The Royal Institution and the late Prof. Hughes.—At a general monthly meeting of the members of the Royal Institution on Monday, the chairman, Sir James Crichton-Browne, M.D., F.R.S., reported the death of Prof. David Edward Hughes, F.R.S., a manager of the Royal Institution. It was resolved to express to Mrs. Hughes their heartfelt sympathy in her sad bereavement, and the deep regret of the managers in losing by the death of Prof. Hughes a most valued colleague. Prof. Hughes became a member of the Royal Institution in 1882. He delivered a discourse on the theory of magnetism on February 8th, 1884. As a manager and vice-president, he rendered important services to the Institution, and his scientific researches, which had received world-wide recognition, had done much to promote the objects of the Institution.

NEW COMPANIES REGISTERED.

Thomson-Davis Telephone System, Limited (64,901).—This company was registered on January 30th, with a capital of £6,000 in £1 shares, to adopt an agreement with A. T. M. Thomson and P. W. Davis for the acquisition of certain patents relating to improvements in telephone systems and apparatus, and to carry on the business of manufacturers of and dealers in electrical, magnetic, and scientific appliances, telephones, telegraphic apparatus, &c. The first subscribers (each with one share) are:—Percy W. Davis, 61½, Fore Street, E.C., ivory and metal plater; Edward Maxwell-Davis, 61½, Fore Street, E.C., director; Arthur T. M. Thomson, 100, Great Clowes Street, Lower Broughton, Salford, Manchester, electrical engineer; John P. Bell, 61½, Fore Street, E.C., secretary; John H. S. Thomson, Broad Street House, E.C., secretary; Max Byng, 71, Queen Victoria Street, E.C., manufacturer and engineer; and Fred. Samuelson, 46, Queen Victoria Street, E.C., solicitor. The number of directors is not to be less than two nor more then seven; the first are A. T. M. Thomson, P. W. Davis, and M. Byng; qualification, £100; remuneration as fixed by the company.

C. Evans & Co., Limited (64,902).—This company was registered on January 30th, with a capital of £10,000 in £1 shares, to acquire the business carried on by C. Evans, and to carry on the business of mechanical and electrical engineers, ironfounders, brassfounders, makers of railway and other signals, magnetic and electrical apparatus manufacturers, &c. The first subscribers (each with one share) are:—Walter E. Reynolds, 110, Portsdown Road, Maida Vale, W., clerk; Theodora Titzé, 20, Lisle Street, W., clerk; James B. Dick, Carlton Hotel, S.W., comptroller; Gustave Fabesch, Buffet Maritime, Boulogne-sur-Mer, restaurant manager; Sam Karl, 33, Portsdown Road, Maida Vale, clerk; Fred Pammant, 23, Rathmore Street, Charlton, S.E., clerk; and H. C. Beloe, 39, Barrett's Grove, Stoke Newington, N., clerk. The number of directors is not to be less than two nor more than five; the subscribers are to appoint the first; qualification, £100; remuneration, £100 per annum, divisible.

CITY NOTES.

City and South London Railway Company.

Mr. C. G. Mott presided at the meeting of this company held at Winchester House on Monday. In moving the adoption of the report, he said that this was the first time since the opening of the line that they had had to meet the shareholders with a reduced dividend. Hitherto they had recommended steadily increasing dividends, but the present reduction was entirely due to the fact that they had to pay a dividend on an increased amount of ordinary stock which has been issued to provide the funds for carrying out the extensions, which were not yet opened and were giving no return. As far as the existing railway was concerned they were in practically the same position as at this time last year, and would have paid the same dividend but for the additional stock. They had suffered a little, with all other railways, in expenses by increased cost of material, coal, and other stores purchased, but the amount had been small, and the actual receipts had been very much the same as a year ago. They would have had a better return altogether in receipts but for the County Council tramway competition. That had affected the company's short distance traffic; as regards the general traffic—the long distance and residential traffic—they had had a satisfactory increase, but it had been counterbalanced by the diminution in the short distance traffic. They were specially interested in the opening of the extensions which they had made, so that they could return sufficient to pay the expenses incurred upon them, and the interest, and from which they hoped to have a considerable surplus to go in augmentation of their dividend. They have been very disappointed because the extension to Moorgate Street was not opened. They had anticipated that it would be opened in October, but electric railways were not like steam railways, you must have everything, however small, in perfect order before you could open an electric railway, and the whole system of working was so inter-dependent that it was not possible to open for traffic until every detail was completed. Having a number of different contractors on a railway like this, with their different special appliances it had been difficult to get them all to keep up to the mark, and the result had been that the opening had been postponed from day to day and from week to week, much to their disappointment, but he believed that there was every probability that they would open the Moorgate Street extension some time within the next fortnight. He did not like to say positively that it would be so, as the very smallest failure in any one department would prevent it, but they had already run experimental trains over the extensions, and it was only the smaller details that prevented their opening to the public as soon as the Board of Trade have given their requisite certificate. After the meeting shareholders would have an opportunity of paying a visit to the Bank Station at Lombard Street, under St. Mary Woolnoth Church. The extension to Clapham was, as far as the tunnelling arrangements and the underground work were concerned, practically complete; the surface stations were not yet ready but they were going up fast, and there were various other details which would have to be carried out, but they hoped within three months to be able to open that extension also. There will then remain only the Islington extension. That was proceeding, more than a fourth of the tunnelling had been executed, and the underground stations were beginning. He was sorry that they had had some delay, and were still having it in regard to the Islington work through the difficulty of settling matters with the London County Council. They were a most difficult body to deal with. At Islington the company bought houses with long gardens built at the time when the place was in the country. The London County Council now told them that they could not cover those gardens with any kind of building whatever, and the public must approach their station over these and stand outside in the wet. The directors wanted to put a one storey building on the frontage. They had offered to give up a portion of that to the public if they were allowed, and so far they had not permission even to put a one storey covering to protect passengers. They were still negotiating, but that all meant delay, and it was unfortunate that probably those things would delay the opening of the Islington extension for a short time. Public things of this kind which were for the benefit of the public, and gave shareholders only a very moderate return at the best, ought to be encouraged by the public bodies, and obstruction should not be put in the way of their being carried out. As to the question of accommodation, they had always seriously considered the desirability of connections with other railways. It was one of the most important things for the public convenience, and also for the reduction of the traffic in the streets of London, that underground connections should be made between those underground electric railways. They had arranged with the Brighton Company for a subway at London Bridge. There had been some delay in the question of proceeding with that, but he hoped it would not be many weeks before the works would be put in hand; the agreements were all settled. They had also arranged with the Great Northern and City for a joint station at Old Street. Some details were yet remaining to be settled as to the working of that station, but the works were going on. There was a Bill before Parliament for an extension to the Baker Street and Waterloo Railway from the Baker Street end to Paddington, and from the Waterloo end to the City and South London Station at the Elephant and Castle. He hoped that would be proceeded with, as it would be a very great public convenience to have a connection from the South of London to the busiest West End parts of the metropolis. It would do a great deal for the revenue on this company's line. The company had a Bill in Parliament which shareholders would be asked to approve for an alteration of the station at Islington. Having determined that the Islington station should be their final terminus, at present at all events, they had been trying to make that station as convenient as possible for the working, and they found that it would be much better to do as they had done on the Clapham extension, and that was to make one very large arch of 30 feet in width rather than two smaller ones. It added very much to the safety of working and to the convenience of that station. The original Bill would not allow that it was got before they had tried 30 feet station tunnels. They could not do it without an Act of Parliament, but it would not be a costly procedure, because there was no probability of opposition from anyone. Turning to the accounts, in the first place, under capital account, they had received in calls on shares during the half-year £105,703, and on debentures and premiums of £12,075, making a total of £117,778. They had expended £178,6 6, and the balance of that went to the debit of capital. An increase of £60,688 had been made. They had borrowed this on their debenture stock rather than issue it during the latter part of last year when they would have had to take a very much lower price than they would have done by keeping it. They preferred to raise money in that way rather than issue permanent stock at a very low price. In regard to the revenue account, they received from passengers £122 less on the half-year. That was due to the diminution of short distance passengers and also to a little difficulty with the season-ticket holders, which was now set right. Parcels, transfer fees, and rents, showed decreases; sundry receipts showed increases resulting in a net decrease of only £82 in the receipts for the half-year. As to expenditure the maintenance charges decreased £134, carriage repairs were down £66, law charges £2. On the other hand, locomotive and generating charges appeared as increases, £367, chiefly due to coal. Traffic expenses £118, general expenses £56, rates and taxes £111, making a total net increase of £470. This with the decreased receipts of £82, made a decreased net profit of £552. They had an increased interest on the debenture stock of £1,128, an increase on the first issued preference dividend of £1,279; on the other hand, that had increased interest of

£2,818, which left them with a debit of £141, and the dividend of 1½ per cent. on the new stock was the same as the dividend of 2 per cent. on the old stock within £112. That and the alteration in the balance carried forward made a difference of £253. The number of passengers had decreased for the half-year by 19,872. They seldom had a decrease under this head, but it had arisen from the short distance passengers. They had had a considerable decrease, but the residential and longer distance passengers had shown a steady increase. They had run during the half year 7,807 more miles. They had increased the number of trains. As to the number of passengers per train, of course, with increased train mileage and a decreased number of passengers, the number per train had slightly decreased—it was only 44·82 against 46 58 in the corresponding period of the previous year. The receipts per train mile were 2s. 3·28d. against 2s. 4·28d.—1d. per train mile less. Receipts per passenger were about the same. The working expenses were 58 05 per cent. against 56 18 per cent., and most other railway companies in England were also up in that respect. The expenses per train mile are 1s. 3 84d. against 1s. 3 88d., a slight decrease. The locomotive charges are 5 85d. against 5·65d. These figures showed that the line was working very much on the old lines. There was practically no alteration, and if it had not been for the question of the new capital they would not have had to show a balance insufficient to keep up the dividend to its former figure. Their new generating station was nearly complete, and the engines at least are now running satisfactorily. Everything pointed to their being able to work the extension in an economical way and giving satisfaction to the public.

After a few questions had been asked and answered, the report was adopted, and resolutions declaring the dividend, re-electing directors and auditors, and giving thanks to the board, were unanimously passed.

At an extraordinary general meeting, which followed immediately a resolution was passed approving of the Bill now before Parliament for altering the size of the Islington tunnels, mentioned in the chairman's speech.

Smithfield Markets Electric Supply Company, Limited.

The directors in their report and the accounts for the 15 months ended December 31st, 1899, say:—

"The gross revenue amounts to £12,083 6s., against £6,501 5s. 2d. for the year ending September 30th, 1898, while the gross profit on trading has been £3,435 0s. 9d., against £759 3s. 1d. for the same period. This result would have been even better but for the difficulty which the company has experienced, in common with all other electric lighting companies, in obtaining the best quality of steam coal, and the consequent largely increased consumption. Nevertheless, further reductions have been effected in the costs per unit generated and sold. The net profit for the 15 months, after paying debenture interest and other charges, is £564 18s. 2d., thus reducing the deficit existing at September 30th, 1898, to £210 2s. 8d. This amount will, it is anticipated, have been more than wiped off by the end of January, 1900. The conviction expressed by the directors in their last report that the use of electricity in the Central Markets was likely to become more popular has been borne out by results. During the period covered by the accounts, 78 new installations have been obtained, and the increase in the number of lamps connected has been 7,237, or 74 per cent. As about one-half of these lamps were connected during the last three months of the year, the full effect on the revenue will only be apparent in the current year's accounts, which should show a further substantial increase. New customers are constantly being obtained, and several are at present waiting to be connected. The plant and machinery has been worked satisfactorily throughout, no interruption of any kind having occurred in the supply. The storage battery has been in use since October last with economical results. The value of this battery in the saving of coal and wages will be considerably enhanced during the summer months, as it will enable the plant to be shut down for several hours per day, as well as ensuring against failure in the supply at all times. The directors regret that their application for a provisional order to enable them to supply current in the City of London was unsuccessful. The cost of the application will be spread over a period of five years. Mr. H. S. Leon has been appointed a director to fill the vacancy caused by the retirement of Mr. G. H. Brougham Glasier. The director retiring under the articles of association is Mr. Ernest Schenk, who, being eligible, offers himself for re-election. The auditors, Messrs. Ford, Rhodes & Ford, also retire and offer themselves for re-election."

The Kensington and Knightsbridge Electric Lighting Company, Limited.

The report of the directors, to be presented at the thirteenth ordinary general meeting to be held at 1, Great George Street, Westminster, on Wednesday, February 14th, reads as follows:—

"The directors submit to the shareholders a statement of the accounts of the company, together with a report of the position of the undertaking at the end of the year 1899. During the year the number of houses and shops connected with the system has increased from 1,851 on December 31st, 1898, to 2,110 on December 31st, 1899, while the number of lamps calculated on the usual basis of 8 c.p. has increased from 156,158 to 183,462. The directors have strengthened the renewal account by transferring to it £4,764 9s. 10d., making the total amount placed to that account £30,379 19s. 7d. After providing for the above amount, and paying the dividends on the 6 per cent. first preference shares to June 30th, 1899, on the 5 per cent. second preference shares to September 30th, 1899, and an interim dividend at the rate of 10 per cent. per annum on the ordinary shares for the first half of the year, the balance standing to the credit of the net revenue account for the year 1899 is £10,297 15s. 5d. Of the above sum, £1,450 has been appropriated to the payment of the first preference dividend to the end of the year, and £404 has to be set aside to meet the portion of the dividend on the second preference shares accrued to the same date, leaving £8,443 15s. 5d., out of which it is proposed to pay a further dividend on the ordinary shares of 6 per cent. for the past half-year, making, with the interim dividend paid on August 3rd, 11 per cent. for the year. This will leave a balance of £4,093 15s. 5d. to be carried forward. The directors are glad to be able to state that the Bill in Parliament, which was approved by the shareholders at the commencement of last year, for the purpose of obtaining powers to erect a new generating station at Wood Lane, in conjunction with the Notting Hill Electric Lighting Company, Limited, has passed into law, having received the Royal Assent on July 13th last. The directors believe that the powers thus secured will afford substantial advantages to both the companies interested. No time has been lost in proceeding with the necessary steps for carrying the scheme into effect. The land has been acquired, and contracts for the erection and equipment of the new works have been placed. The directors hope that before next winter the new station will afford an effective addition to the company's sources of supply. The cost of the new station will be borne by this company and the Notting Hill Company, in proportion to the extent to which each company shall participate in the output of the new works. This company will therefore have to make provision for its proportion of the capital expenditure required. Your attention is called to the circular enclosed with this report, with reference to the issue of the balance of the 5 per cent. second preference shares. In accordance with the articles of association, Mr. R. W. Wallace, Q.C., and Sir Charles Grant, K.C.S.I., retire from the directorship, and being eligible, offer themselves for re-election. The auditors, Messrs. Lovelock, H. W. S. Whiffin & Dickenson offer themselves for re-election."

Anglo-American Telegraph Company.

On Friday last the meeting of this company was held at Winchester House, E.C., Mr. F. A. Bevan, presiding.

In moving the adoption of the report and accounts, the Chairman said that they had great pleasure in giving such a satisfactory account of the working of the cables during the past half-year. The traffic receipts had amounted to £197,318, being an increase over the corresponding half of last year of £6,797. The charter of the ss. *Minia* brought in £9,853, an increase of £6,050; adding an increase of £335 in interest, the total increase in receipts was £13,183. On the other side the working expenses were £47,412, an increase of £869, which was not a large increase considering the increased traffic and receipts. The expenses are now only 37 per cent., there having been a gradual decrease since 1894, when they were 48 per cent., to 37·5 per cent. to-day, which he thought reflected great credit upon the management. The traffic was carried on as efficiently, or more efficiently than ever. Rather a large sum was spent on cable repairs, including the cable, viz., £18,060, an increase of £3,040. That increase included work done upon the cables of their friends, for which they had received £9,850. The receipts increased by £13,162, the expenses by £3,766, a net increase, therefore, of £9,360 for the half-year; £24,701 was brought forward. The result was that they had £153,605 divisible, after setting aside £12,000, which was put to the renewal fund; £152,250 was to be divided, the preferred shareholders getting £3 13s. 6 l. for the year and the deferred £1 7s. This was the first amount paid to the deferred since 1878. £1,355 was being carried forward. That was a very satisfactory account. Referring to the details of the renewal fund during 1899, this had increased from £765,000 to £820,000, of which £730,000 was invested in securities, £40,000 in cable, and between £20,000 and £30,000 in premises in Throgmorton Street, and the remainder was practically their working capital. The increase has been made up of £24,000 from revenue, £23,513 interest, and £6,778 profit on the sale of securities, making altogether £54,291. Securities had depreciated in value during the year, but there was still a surplus, though but a comparatively small one on the valuation of their securities, over the £730,000 at which they stood in the books. A considerable portion of the deferred dividend represented earnings of their ss. *Minia*, employed for their friends, and it was a precarious item of revenue, and besides, they had the possibilities of what might happen to them through the laying of the new German cable. The Anglo-American Company's agreement with the German Government expired on the last day of 1899, and they might, naturally enough, expect him to say that during the past month of January the company had been carrying no traffic from Germany. The shareholders would be pleased to hear, however, that up to the present the company were carrying the German messages exactly as during the continuance of the agreement; but how long this would last it was not for him to say. The German company did not seem to have so far matured their arrangements as to be able to dispense with the valuable assistance of the Atlantic cables, and therefore, though they had said nothing, they continued to give them the messages. However, a new cable would be laid between Germany and America by the Azores this year, and there was no doubt that a large proportion of the German traffic from this side, which the company had hitherto carried to the entire satisfaction of the German Government, would be diverted to that cable. It was probable that they might still be able to get some of the German messages, even from this side, while their partners, the Western Union Company, the Direct Company, and they them-

selves would, he believed, get a good deal of the German traffic from the other side of the Atlantic. The German company were anxious to arrange for an alternative line in view of the possible interruption of the new cable, and they also wished, if possible, to secure the whole of the traffic from America and Germany. In order to obtain that they had entered into some arrangement with the Commercial Company. They might have thought the arrangement would have so matured by the end of last year that the German company would have said good-bye to this company, but for some reasons they did not seem to send any more messages by the Commercial cable as yet. One of the objects aimed at between those two companies required the sanction of the British Government, but it being represented to the British Government that the interests of holders of British cables would be seriously injured if this proposed arrangement was carried out, the Government refused to give their sanction to the arrangement, and the company were very much indebted to the British Government for having taken that proper and patriotic view. So for the present, pending the laying of their own cable, the Germans were sending their messages by this company, but they could scarcely expect that this would last beyond the time when the new cable was laid. He was afraid they might then expect a falling off in the traffic, but, on the other hand, there was always a normal growth of traffic, and if their lines were maintained in efficient working order, and attention given to keeping down expenses, they should still be able to do a good business. How far the deferred were likely to get the dividend paid them this year it was not for him to say. They might like to hear something about that old affair, the French lawsuit. As he told them on the last occasion, the company had a decision given in their favour for £258,000, and the whole of the details were referred to a committee of experts, to see whether they could not find out something to set off against this £258,000. After the Long Vacation the experts met, and the company's solicitor and manager had paid more than one visit to Paris. The experts were still at work, but how long they might be at work he did not know. They had some very curious figures put before them by the other side, and how long they would take to make up their minds he could not say. The Chairman concluded by moving the adoption of the report and the declaration of the dividends.

Sir Gerald Fitzgerald seconded the resolution.

In reply to a question, the Chairman said that the laying of the Pacific cable seemed some way off, but he might say, without any breach of confidence, that the Anglo-American board had been approached by the promoters of the scheme, and asked whether some arrangement could be entered into.

The report was unanimously adopted, as were also resolutions declaring the dividends, re-electing directors and auditors, &c.

Great Northern and City Railway Company.

Sir Charles Scotter, chairman, presided on Thursday last week at the Westminster Palace Hotel over the third half-yearly meeting of the above company, and in moving the adoption of the report, said he had little to tell the shareholders except what was contained in the report of the engineers. He had just had placed in his hands the report of Sir Douglas Fox and his partners, which was as follows:—"At Finsbury Pavement no commencement has yet been made, but possession has been obtained of both the properties for the station site. Negotiations with regard to the temporary shaft in Finsbury Square have been completed, and an agreement has been drawn up. The contractors expect to start here at an early date, and besides constructing the station and cross-over tunnels, they propose to start driving the main line tunnels northwards to meet those being driven southwards from Regent's Canal. The rate of progress on this section of the railway will thus be doubled. At Old Street possession has been obtained of one of the properties of the station site, and the 30 feet diameter lift shaft has been sunk to a depth of 28 feet. Negotiations are in hand as to the construction of the station tunnels here. At Regent's Canal the up-line tunnel has been driven for a distance of 179 lineal yards northwards and 153 lineal yards southwards, and the down-line tunnel for a distance of 117 lineal yards northwards and 76 lineal yards southwards. At Essex Road Station the 21 feet diameter station tunnel for the down line has been commenced, and 8½ lineal yards have been completed. About 300 tons of cast-iron segments for this tunnel are delivered. At Drayton Park the down-line tunnel front has been completed. At Canonbury the up-line tunnel front will be started on Thursday, the 1st prox. As soon as the tunnel front is completed the contractors propose to start driving the main-line tunnel southwards to meet those being driven northwards from Regent's Canal, thus doubling the rate of progress on this section also. There are about 300 tons of cast-iron segments at Regent's Canal, about 1,000 tons at King's Cross Station, and in all about 6,700 tons have been passed by our inspectors; 480 men were employed at the works last week." He might also say that they had had the experience of the Central London Railway, which was nearly completed. They would have the benefit of all the experience that had been gained in constructing that railway with the electric appliances they might adopt, and they also benefited by the experience of the Waterloo and City railway, of which he was a director. That railway was made under rather difficult circumstances, and they adopted a system of traction which was at the time thought best, but experience had shown that some alteration was necessary, and the working company had now ordered new motors, and it was expected that in the course of a few months the working of that railway would be very much improved, and so much cheapened that it would become a financial success. He did not mean to say that the City and Waterloo railway was a financial failure because the shareholders were getting 3 per cent., and those people ought to be content with 3 per cent. or 4 per cent. However, there was no doubt but that the experience which would be gained from the Central London railway and the City and Waterloo railway would be of great advantage to their line. Their railway would pass through densely populated districts, and if they could only secure a cheap mode of working and a frequent service, the success of the undertaking was practically assured.

The Earl of Lauderdale seconded the motion.

Mr. Royal called attention to the very congested state of the traffic on the Great Northern Railway, and referred to the efforts being made by the local bodies in the districts served by that railway to get improvements. He felt that the Great Northern and City line would be an immense boom, and asked when it was likely to be completed.

Mr. Le Mare asked if it was a fact that the Great Northern Railway Company was inclined to shunt the company, and if it was a fact that the Great Northern Company were under an engagement to run a certain number of trains on the Great Northern and City.

Col. Laurie said he noticed that there was an estimated capital expenditure of £170,000 for the next half-year, and he asked when a further call would be made.

The Chairman said that in the agreement with the contractors the line had to be completed by the end of June, 1902, and that was stated plainly in the prospectus. There was no doubt that the suburban traffic all round London was so great that it was necessary to have such lines as theirs in all districts. With regard to the relations existing between their company and the Great Northern Railway Company, as they knew the line was originally projected almost at the suggestion of the Great Northern, and when the company was first formed the Great Northern directors were on the board. The first company did not succeed in its appeal to the public. Ultimately, Messrs. Pearson & Sons, the contractors, took the concern in hand, and then there was a little shyness on the part of the Great Northern Company. However, he could not say that there was a strained feeling between the companies, but would put it another way, and say that the relations were getting better, and they would soon be on as good terms as they were at the commencement. With regard to a call, the notices were now out.

The report was then adopted, and the retiring directors were re-elected.

St. James's and Pall Mall Electric Light Company, Limited.

The directors' report for the year ending December 31st, 1899, to be submitted to the meeting of shareholders at the offices, Carnaby Street central station, on Tuesday, February 13th, reads as follows:—The directors submit their report for 1899, with the accounts as certified by the company's auditors. The Carnaby Street and Mason's Yard stations have been working satisfactorily throughout the year, and have proved fully adequate to meet the largely increased demand for current. The Bill mentioned in the report for 1898, authorising the company to acquire by compulsory purchase certain property adjacent to the Carnaby Street station, has received the Royal assent; the property has been acquired, and the extension of the station is in progress. The Bill promoted by this company in conjunction with the Westminster Electric Supply Corporation, Limited, under the title of the "Central Electric Supply Company, Limited," authorising the establishment of a station on certain property to be acquired in the parish of St. Marylebone, has also received the Royal assent, and steps are being taken to give effect to its provisions. The 100 founders' shares of £1 each, which formed part of the original capital of the company, have been cancelled, and their nominal value has been carried to capital reserve account. 8,020 ordinary shares, the balance of the new capital created in February, 1898, and January, 1899, were offered to the shareholders, *pro rata*, in October last at a price of £12 10s. per share, and have all been issued. The premium on calls payable up to December 31st, 1899, amounting (less expenses) to £36,923 0s. 11d., has been carried to capital reserve fund. On the other hand, the premium of 5 per cent. paid on the redemption of the debenture stock, amounting to £2,500, has been charged to this account.

	£	s.	d.
The net earnings of the company for the year 1899 were	31,834	9	10
Less interim dividend paid in August last for half-year ending June 30th, at rate of—			
7 per cent. on preference shares £3,500 0 0			
10 per cent. on ordinary shares 7,995 0 0			
	11,495	0	0
	20,339	9	10
Balance brought forward from 1898	88	19	1
Leaving an amount now to be dealt with of	£20,428	8	11

The directors propose to divide this amount as follows:—

	£	s.	d.
(*a*) By payment of a dividend at the rate of 7 per cent. per annum on the preference shares for the second half of the year ..	3,500	0	0
(*b*) By payment of a dividend on the ordinary shares for the second half-year of 7s. 6d. per share, and a bonus of 2s. per share, making, with the interim dividend paid on August 1st last, a total distribution of 1½ per cent. for the year	15,190	10	0
(*c*) Amount to be carried forward	1,737	18	11
	£20,428	8	11

The chairman, Mr. Eustace J. A. Balfour, and Sir John H. Morris, K.C.S.I., are the directors who retire by rotation under clause 79 of the articles of association, and being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths & Co., also retire, and being eligible, offer themselves for re-election.

Stock Exchange Notices.—The Stock Exchange Committee has appointed special settling days as under:—Wednesday, February 14th.—Chelsea Electricity Supply Company, Limited—Further issue of £50,000 4½ per cent. debenture stock, and has ordered same to be quoted in the Official List; and also Buenos Ayres and Belgrano Electric Tramways Company, Limited—Further issue of £54,415 5 per cent. debenture stock. Western Telegraph Company, Limited—Further issue of 1,937 shares of £10 each, fully paid, Nos. 205,994 to 207,930.

The Charing Cross and Strand Electricity Supply Corporation, Limited.—The directors, after providing £8,000 for depreciation and carrying forward £4,400, have decided to recommend a dividend for the half-year ended December 31st, 1899, at the rate of £10 per cent. per annum (making with the interim dividend distributed for the half-year ended June 30th, 1899, at the rate of 8 per cent. per annum) a dividend payable for the year 1899 of £9 per cent. on the ordinary share capital, as against 8 per cent. for the year 1898.

Oldham, Ashton and Hyde Electric Tramway, Limited.—The preference share transfer books and register of members will be closed from 5th to 15th inst., both dates inclusive.

Bournemouth and Poole Electricity Supply Company.—The transfer books and register of members will be closed from 5th to 14th inst., both dates inclusive, preparatory to payment of the dividend on the preference shares.

The Indo-European Telegraph Company, Limited.—Mr. W. Andrews has resigned his position as managing director of this company, and Mr. T. W. Stratford-Andrews has been appointed in his place.

St. James's and Pall Mall Electric Light Company.—The share transfer books will be closed from February 7th to February 21st, inclusive, preparatory to the payment of dividends for the half-year ended December 31st, 1899.

Telegraph Construction and Maintenance Company, Limited.—Subject to audit, the directors propose to pay a dividend of 10 per cent., in addition to the 5 per cent. already paid, making 15 per cent. for the year 1899.

TRAFFIC RECEIPTS.

Blackpool and Fleetwood Tramroad Company.—The receipts for the week ending February 3rd, 1900, were £167 14s. 1d.; receipts for corresponding period, 1899, £172 18s. 5d.; aggregate for half-year to date, £740 19s. 8d.

The Bristol Tramways and Carriage Company, Limited.—The receipts for the week ending February 2nd, 1900, were £2,476 3s. 10d.; corresponding period, 1899, £2,274 12s. 6d.; increase, £201 11s. 2d.

The City and South London Railway Company.—The receipts for the week ending February 4th, 1900 were £1,119 ditto February 5th, 1899, £1,135; decrease, £16. Total receipts for half-year, 1900, to date, £5,590; corresponding period, 1899, £5,652; decrease £62. Miles open, 1½

The Dover Corporation Tramways.—The receipts for the week ending February 3rd, 1900, were £149 16s. 2d.; February 4th, 1899, £124 19s. 6d.; increase, £24 16s. 8d. Total receipts to date, 1900, £756 5s. 2d.; corresponding period, 1899, £711 19s. 7d.; increase, £44 6s. 7d. Miles of track open, 1900, 3; 1899, 3. Car miles run, 1900, 4,867; 1899, 4,265. Number of cars, 1900, 11; 1899, 11.

The Dublin United Tramways Company.—The receipts for the week ending Friday, February 2nd, 1900, were as follows:—D. U. T. Co., horse cars, £81 16s. 8d.; ditto, electric cars, £2,789 2s. 9d.; D. S. D. Co., electric cars, £569 13s. 2d.; total, £3 440 11s. 7d.; corresponding week last year—D. U. T. Co., horse cars, £1,685 16s. 4d.; ditto, electric cars, £894 9s. 8d.; D. S. D. Co., electric cars, £545 11s. 2d.; total, £3,055 17s. 2d.; increase, £384 14s. 5d. Aggregate to date, £16,541 18s. 8d.; aggregate to date last year, £15,016 2s. 4d.; increase to date, £1,515 16s. 4d. The mileage worked is 41 miles electrically, 3 miles by horses, as against 18 miles electrically, 26 miles by horses, for the corresponding period last year.

The Halifax Corporation Tramways.—The receipts for the week ending February 4th, 1900, were £520; February 8th, 1899, £273; increase, £247. Number of cars, 1900, 28; 1899, 15. Total receipts to date, 1900, from April 1st, 1899, £26,014; 1899, from June 29th, 1898, £8,462. Miles of track open, 1900, 12; 1899, 6¼.

The Liverpool Overhead Railway Company.—The receipts for the week ending February 4th, 1900 amounted to £1,527; corresponding week last year £1,273; increase, £254; total for half-year to date, £1,020.

The South Staffordshire Tramways Company.—The receipts for the week ending February 2nd, 1900, were £660 16s. 1d.; February 3rd, 1899, £587 8s. 4d. Aggregate receipts for 5 weeks, £3,010 1s. 10d.; last year, £2,895 14s. 2d.

STOCKS AND SHARES.

Wednesday Evening.

WITH all eyes turned towards the Transvaal, and the utmost tension existing with regard to the safety of Ladysmith, it is not surprising that electrical markets should still be suffering from lack of business. The existing condition of the supply department, for instance, is very different to what it was 15 months ago, when the market was in high boom and speculation in lighting shares spread every day. It is now a matter of congratulation to the jobber who does 20 bargains a day in the shares. On the whole, however, the altered state of affairs distinctly makes for the good of shareholders, who do not want to see their securities being tossed to and fro by the speculators who always "make for" a lively market. The best of the companies have now settled down into steady-going dividend payers, whose prices rarely fluctuate to any great extent, and the investor who knows that his money is in a good concern, such as St. James's or Westminster Electric shares, can well afford to disregard political or other foreign influences which may depress his shares for the time being, but which he knows is merely transitory.

Dividends and reports are now making their appearance every day. It is too early yet to institute a comprehensive comparison of results attained in 1899 with those of 1898, but a week or two more will probably see the data ready to our hand. The most interesting feature of the reports now before us is the steady growth, not only of receipts, but of expenditure. As an example, we may instance the "Jimmy" report. The St. James's and Pall Mall Company, according to this document, has earned a substantially increased profit as compared with the last six months of 1898, but the other side of the account exhibits increases in almost every item. Nor, while the present conditions governing the labour, copper, and coal markets continue, do we see much hope of a reduction in these expenses. It is the despairing cry of all the chairmen at meetings of railway and industrial concerns generally, that everything is so dear, and, of course, electrical companies are closely touched by all the trio of markets we have mentioned.

Charing Cross and Strand Ordinary—both old and new—are better on the dividend announcement, but "Jimmies" fell on Tuesday, despite their report, which was considered a favourable one. London Electric Supply are a weak market; the Ordinary and Preference are down 5s. each, but the Debenture stock has appreciated a little. Other quotations in this list are virtually where they were at the beginning of the year, having recovered in most instances from the shocks that shook all the Stock Exchange markets, as the news of the various checks to British Arms in South Africa were cabled over.

Anglo-American Telegraph stocks have failed to sympathise with the general markets this week. The Deferred, in fact, has shed a small fraction, but quiet investment buying helps to keep the price of the "B" stock from declining. The price is now about 116. At 120 the return to a purchaser is exactly 5 per cent., which is a good yield nowadays. Anglo "B" stands every chance of a rise when the Money Market becomes more settled.

The War Cable Companies' securities are unaltered on the week, except for a nominal widening of the price of Eastern 3½ per cent. Preference stock. The Eastern Company has had a bad week on the whole, owing to the rigorous censorship now being exercised, but we understand that its Oriental business is good. The price of the Ordinary stock is still 155½, and the market is by no means sorry to notice signs of a split on the All-British Cable Commission. Cuba Telegraph Ordinary have moved up, a slight demand for the shares having arisen amongst those who fancy Cuban investments, now that the island is recovering from its former distress. Globe Telegraph and Trust Preference are also better. They have now reached a 4 per cent. level, and would appear to be quite sufficiently high in price. The Ordinary have much better hopes for an improvement in the near future, but the market for the moment is quiet.

Very little fresh news transpired at the meeting of the City and South London Railway on Monday. There does not seem to be any hope of County Council assisting such enterprises, as the chairman of the City and South London suggested in his speech. The price of the stock is no better, but the new shares are down to 4½. On the Ordinary stock the yield to an investor at the present quotation of 60 is $3\frac{7}{16}$ per cent. British Electric Traction are quiet; the new shares are quoted 16, which is ½ below those of the previous issue.

Some weeks ago we were remarking that shares in the manufacturing companies possessed good prospects of advancing in value, and there is now a move being made in this direction. Last week it was British Insulated Wire which advanced 30s. This week it is Henleys and Electric Constructions that are better. We should not be surprised to see Telegraph Manufacturing go better shortly; the shares have been stationary for a long while. It must, however, be borne in mind that coal and copper both play important parts in the industry with which these manufacturing companies are connected. National Telephone shares have not moved, the damage done by the snowstorm of Friday last having proved more inconvenient than expensive.

A transparent slip occurred in these notes last week with regard to Smithfield Market shares, a reference being made to the meeting, instead of to the report of the company. The meeting will be held on the day that this issue appears. A correspondent who has also noticed the mistake, takes us to task because we "do not write in a friendly manner towards this company." We must, however, point out that it is not our business to write in any particular way upon any subject. It is unnecessary to add that these notes are absolutely impartial: they have no bias either way as regards anything in the market, and if the ways of a company do not commend themselves to us, or if the price of the shares falls, of course we have no hesitation whatever in saying so.

SHARE LIST OF ELECTRICAL COMPANIES.—TELEGRAPH AND TELEPHONE COMPANIES.

Present Issue.	NAME.	Stock or Share. †	Dividends for the last three years. 1897.	1898.	1899.	Closing Quotation, Jan. 31st.	Closing Quotation, Feb. 7th.	Business done during week ended Feb. 7th, 1900. Highest.	Lowest.
110,900	African Direct Telegraph, 4 % Debs.	100	...	...	...	99 —103	99 —103	...	...
25,000	Amazon Telegraph, shares	10	...	...	...	3 — 4	3 — 4	...	...
125,000	Do. do. 5 % Debs., Nos. 1 to 1,250 Red.	100	...	...	...	85 — 90	85 — 90	...	...
875,520	Anglo-American Telegraph	Stock	3 %	£3 9s	73/6	65 — 68	65 — 68	...	...
3,062,240	Do. do. 6 % Pref.	Stock	6 %	6 %	6 %	115 —116	115 —116	116	115½
3,062,240	Do. do. Deferred...	Stock	...	18s. %	£1 7s	17 — 17½	16¾— 17¼	17¼	17
44,000	Chili Telephone, Nos. 1 to 44,000	5	4 %	...	...	2 — 3	2 — 3	2⅜	2¼
10,000,000$	Commercial Cable	$100	8 %	8 %	...	165 —175	165 —175	...	...
1,382,823£	Do. do. Sterling 500 year 4 % Deb. Stock Red.	Stock	...	...	...	102 —104	102 —104	104	103½
224,850	Consolidated Telephone Construction and Manufacturing	10/-	1½%	1 %	...	¼— ¼	¼— ¼	...	...
16,000	Cuba Telegraph	10	7 %	8 %	...	8¼— 9¼	9 — 10	...	...
6,009	Do. 10 % Pref.	10	10 %	10 %	...	19 — 20	19 — 20	...	...
12,981	Direct Spanish Telegraph	5	4 %	...	...	4 — 5	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	...	...	9 — 10	9 — 10	...	...
80,000	Do. do. 4½ % Debs.	50	...	...	...	101—105%	101 —105%	...	...
60,710£	Direct United States Cable	20	3½%	3½%	3 %	11½— 12 xd	11½— 12	11⅞	...
120,000	Direct West India Cable, 4½ % Reg. Deb.	100	...	...	...	99 —102	99 —102	...	...
4,000,000	Eastern Telegraph, Ord. Stock	Stock	7 %	7 %	...	153 —158	153 —158	158	155
1,795,000	Do. 3½% Pref. Stock	100	...	...	...	99 —101	98 —101	100	98
1,432,268£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	...	...	115 —120	115 —120	...	...
250,000	Eastern Extension, Australasia, and China Telegraph	10	7 %	7 %	...	15½— 15⅝	15½— 15⅝	15⅝	15⅜
16,200£	Do. 5 % (Aus. Gov. Sub.) Deb., 1900, red. ann. drgs., reg. 1—1,049, 3,976—4,326	100	5 %	...	...	99 —103	99 —103	...	...
64,400£	Do. do. Bearer, 1,050—3,975, 4,327—6,400	100	5 %	...	...	100 —103	100 —103	...	...
330,000£	Do. 4 % Deb. Stock	Stock	4 %	...	...	117 —122	117 —122	...	...
17,400	Eastern and South African Telegraph, 5 % Mort. Deb., 1900 red., Reg. Nos. 1 to 2,343	100	...	...	...	... ...	... ...	...	...
24,500	Do. do. do. to bearer, 2,344 to 5,500	100	...	...	...	... ...	... ...	...	...
300,000£	Do. 4 % Mort. Debs., Nos. 1 to 3,000, red. 1909	100	...	...	...	101 —104	100 —103	101	...
200,000£	Do. 4% Reg. Mt. Debs. (Mauritius Sub.) 1—3,000	25	...	...	...	101—104%	101 —104%	102	...
180,227	Globe Telegraph and Trust	10	4½%	5½%	...	11 — 11½xd	11 — 11⅛	11 7/16	11⅛
180,042	Do. do. 6 % Pref.	10	6 %	6 %	...	15 — 15½xd	15⅛— 16	15⅝	15½
150,000	Great Northern Telegraph, of Copenhagen...	10	10 %	...	...	30 — 32	30 — 32	...	...
86,300	Halifax and Bermuda Cable, 4½% 1st Mort. Debs., within Nos. 1 to 1,200, Red.	100	...	...	...	99 —102	99 —102	...	...
17,000	Indo-European Telegraph	25	10 %	10 %	...	49 — 53	49 — 53	50½	...
100,000£	London Platino-Brazilian Telegraph, 6 % Debs.	100	6 %	...	...	106 —109	106 —109	...	...
72,680	Montevideo Telephone, Limited, Ord., Nos. 1 to 72,680	1	...	...	2½ %	⅛— ⅛	⅛— ⅛	...	...
86,492	Do. do. 5% Pref., Nos. 1 to 86,492	1	4 %	4 %	5 %	⅞— 1	⅞— 1	...	...
490,000	National Telephone, 1 to 490,000	5	6 %	6 %	...	5⅛— 5⅜	5⅛— 5⅜	5⅜	5⅛
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	14 — 15	14 — 15	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	14 — 15	14 — 15	14⅜	...
250,000	Do. 5 % Non-cum. 3rd Pref., 1 to 250,000	5	5 %	5 %	...	5⅛— 5⅜	5⅛— 5⅜	5⅛	...
1,329,471£	Do. 3½ % Deb. Stock Red.	Stock	3½ %	3½ %	...	98 —100	98 —100	99½	98¾
171,504	Oriental Telephone and Elec., Nos. 1 to 171,504, fully paid	1	5 %	5 %	...	⅞— 1	⅞— 1	...	...
100,000£	Pacific and European Tel., 4 % Guar. Debs., 1 to 1,000	100	4 %	...	...	101 —104	101 —104	...	...
11,839	Reuter's	8	5 %	...	...	7 — 8	7 — 8	...	...
8,381	Submarine Cables Trust	Cert.	...	...	...	125 —130	124 —129	...	...
58,000	United River Plate Telephone	5	5 %	6 %	6 %	4⅜— 5⅛	4⅜— 5⅛	...	...
16,639	Do. do. 5 % Cum. Pref. Nos. 1—16,639	5	...	...	...	4⅜— 5⅛	4⅜— 5⅛	...	...
179,947	Do. do. 5 % Debs.	Stock	...	...	...	103 —106	103 —106	...	...
200,000£	West African Telegraph, 5 % Debs.	100	%	...	...	98 —101	98 —101	...	...
80,008	West Coast of America, Nos. 1—80,000 and 53,001—53,008	2½	...	...	...	¼— 1	¼— 1	...	...
150,000	Do. do. 4% Debs., 1—1,500 gua. by Bras. Sub. Tel.	100	...	...	...	100 —104	100 —103	...	...
389,731	Western and Brazilian Telegraph 4 % Deb. Stock Red.	Stock	...	...	...	100 —104	100 —104	...	...
205,993	Western Telegraph, Ltd., Nos. 1—205,993	10	...	...	...	14¾— 15½	14¾— 15½	15½	14¾
75,000	Do. do. 5 % Debs. 2nd series, 1906	100	...	...	...	106 —109	106 —109	...	...
88,321	West India and Panama Telegraph	10	%	...	...	⅞— 1⅛	⅞— 1⅛	1 1/16	...
34,568	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	...	...	9¼— 9⅝	9¼— 9⅝	9 1/16	...
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	...	...	7 — 8	7 — 8	...	...
80,000£	Do. do. do. 5 % Debs., Nos. 1 to 1,800	100	5 %	...	...	104 —107	104 —107	...	...
158,100£	Western Union of U.S. Telegraph, 6 % Ster. Bonds	100	6 %	...	...	98 —103	98 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

19,661	Brompton & Kensington Elec. Lt. Sup., Ord., 101 to 19,761	5	4 %	6 %	...	7 — 8	7 — 8	7⅞	7⅝
12,000	Do. do. 7 % Cum. Pref.	5	7 %	...	...	8½— 9½	8¼— 9¼	8¼	...
30,000	Charing Cross and Strand Electricity Supply	5	7 %	8 %	9 %	10 — 11	10½— 11½	11	10⅝
20,000	Do. do. do. do. Nos. 30,001—50,000	5	...	...	...	9½— 10½	10 — 11	10	...
20,000	Do. do. do. do. 4½ % Cum. Pref.	5	...	...	...	5⅝— 6¼	5⅝— 6¼	...	...
34,000	*Chelsea Electricity Supply, Ord.,	5	6 %	6 %	...	7¼— 8¼	7½— 8½	...	...
100,000	Do. do. do. % Deb. Stock Red.	Stock	4½ %	...	...	109 —111	109 —111	...	...
60,000	City of London Electric Lighting, Ord. 40,001—100,000	10	10 %	6 %	...	10½— 11½	10½— 11½	11	10⅝
40,000	Do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	...	13 — 14	13 — 14	13⅝	13½
400,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	...	...	122 —127	122 —127	125½	...
40,000	County of Lond. & Brush Prov. Elec. Ltg., Ord. 1—40,000	10	nil	nil	...	9½— 10½	9½— 10½	...	...
20,000	Do. do. 6 % Pref., 40,001—60,000	10	6 %	6 %	...	12½— 13½	12½— 13½	...	...
200,000	Do. 4½% Deb. Stock, Prov. Certs (all paid) Rd.	...	...	...	...	108 —111	108 — 111	110½	...
26,100	Edmundsons Elec. Corp., Ord. Shares	5	5 %	7 %	...	4⅜— 5½	4⅜— 5½	...	...
110,000	London Electric Supply Corporation, Limited, Ord.	8	...	...	...	2 — 2½	1⅝— 2⅛	...	...
48,050	Do. do. do. 6 % Pref.	5	...	6 %	...	5 — 5½	4⅜— 5½	...	...
100,000	Do. do. do. 4% 1st Mt. Db. Stock Rd.	Stock	...	...	...	100 —103	101 —103	...	...
62,500	Metropolitan Electric Supply, 101 to 62,500	10	6 %	5 %	...	14½— 15½	14½— 15½	15½	14⅝
22,500	Do. Nos. 62,501 to 85,000	10	...	...	...	14 — 15	14 — 15	14	...
220,000£	Do. 4½ % First Mortgage Debenture Stock	...	4½%	...	...	115 —117	114 —117	...	...
125,000	Do. 3½ % Mort. Deb. Stock Red.	Stock	...	...	...	95 — 97	95 — 97	95½	...
6,452	Notting Hill Electric Lighting	10	6 %	6 %	...	15½— 16½	15½— 16½	...	...
31,980	St. James's and Pall Mall Electric Light, Ord.	5	14½%	14½%	14½%	15½— 16½	15 — 16	15⅝	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9 — 9½	9 — 9½	...	...
65,000	South London Electricity Supply, Ord.	5	...	...	...	4 — 4½	4 — 4½	...	...
79,900	Westminster Electric Supply, Ord., 101 to 80,000	5	12 %	12 %	13 %	14½— 15½	14½— 15½	15½	14⅝

* Subject to Founder's Shares.
Unless otherwise stated all shares are fully paid.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

† Quotations on Liverpool Stock Exchange.
‡ Dividends paid in deferred share warrants, profits being used as capital

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1897.	1898.	1899.	Closing Quotation Jan. 31st.	Closing Quotation Feb. 7th.	Business done during week ended Feb. 7th, 1900. Highest.	Lowest.
65,000	Aluminium shares, Nos. 1—65,000	1	10 %	...	...	2⅜— 3½	2⅜— 3½	...	...
90,000	Do. 4½ % 1st Mort. Deb. Stock Red.	Stock	...	...	...	95 —100	95 —100	...	...
80,000	British Electric Traction	10	...	6 %	...	16 — 17	16 — 17	16⅜	...
30,000	Do. do. 6 % Cum. Pref. 30,001—60,000	10	...	...	...	13½— 13⅝	13½— 13⅝	13 11/16	13½
200,000	Do. do. 5 % Perpetual Debenture Stock ...	Stock	...	...	...	125 —128	125 —128	128	...
45,000*l*	†British Electric Works Co., Ord. £1 shares, 50,001—95,000	...	...	...	...	⅞— 1	15/16— 1 1/16	...	...
50,000	† Do. do. 6 % Cum. Pref., 1—50,000 ...	...	...	...	...	⅞— 1	⅞— 1	...	...
40,000	British Insulated Wire Ord., Nos. 1 to 40,000	5	...	...	...	13 — 14	13 — 14	...	...
27,500	Do. do. 6 % Cum. Pref. Nos. 1 to 27,500 ...	5	...	...	...	6 — 6½	6 — 6½	...	...
90,000	Brush Elecl. Engng., Ord., 1 to 90,000	3	3 %	5 %	...	1⅝— 2	1⅝— 2	1 13/16	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 %	6 %	...	2⅛— 2⅜	2⅛— 2⅜	...	...
125,000*l*	Do. do. 4½ % Perp. Deb. Stock ...	Stock	...	...	...	110 —115	110 —115	...	...
50,000	Do. do. 4½ % 2nd Deb. Stock Red. ...	Stock	...	...	...	102 —105	102 —105	...	...
20,000	Callender's Cable Construction shares, Nos. 1—20,000 ...	5	12½%	15 %	...	13½— 14½	13½— 14½	14½	...
20,000	Do. do. 5 % Cum. Pref.	5	...	...	...	5½— 6	5½— 6	...	...
90,000	Do. do. 4½ % 1st Mort. Deb. Stock Red.	Stock	...	...	...	110 —115	110 —115	...	...
213,533	Central London Railway, Ord. Shares	10	...	...	...	9½— 10	9½— 10	10	9⅜
61,033	Do. do. Pref. half-shares	5	...	...	...	4½— 5	4½— 5	4 13/16	...
71,447	Do. do. Def. do.	5	...	...	...	4½— 5	4½— 5	...	...
855,000	City and South London Railway	Stock	1⅛%	2⅛%	1⅞%	58 — 61	59 — 62	61	59½
37,000	Do. do. Ord. shares, Nos. 22,501 to 60,000 £5 10s. pd.	10	...	...	...	4½— 5½	4 — 5	...	...
32,098	Crompton & Co., Nos. 1 to 32,098	3	...	...	...	3½— 4 xd	3½— 4	...	...
100,000	Do. 5% 1st Mort. Reg. Debs., 1 to 900 of £100, and 901 to 11,000 of £50 Red.	...	...	...	...	98 —101	98 —101	...	...
99,261	Edison & Swan Utd. El. Lgt., "A" shares, £3 pd. 1 to 99,261	5	6 %	6 %	...	2 — 2½	2 — 2½	...	...
17,139	Do. do. do. "A" Shares, 01—017,139	5	6 %	6 %	...	3½— 4½	3½— 4½	...	...
344,023	Do. do. do. 4 % Deb. Stock Red. ...	100	...	...	...	93 — 95	93 — 95	...	...
112,100	Electric Construction, 1 to 112,100	2	6 %	6 %	...	2 — 2⅛	2⅛— 2⅜	2⅛	2 3/16
25,000	Do. do. 7 % Cum. Pref., 1 to 25,000 ...	2	7 %	7 %	...	2⅜— 3⅛	2⅜— 3⅛	...	...
140,300	Do. do. 4% Perp. 1st Mort. Deb. Stock ...	Stock	...	...	...	103 —106	103 —106	...	...
91,196	Elmore's Patent Copper Depositing, 1 to 70,000 ...	2	...	...	...	⅝— ⅝	⅝— ⅝	...	...
9,600*l*	Greenwood & Batley, 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	7 %	...	10 — 12	10 — 12	...	...
30,000	Henley's (W. T.) Telegraph Works, Ord.	5	12 %	14 %	...	13 — 14	13½— 14½	14	...
12,000	Do. do. do. 4½ % Pref.	5	7 %	7 %	...	5½— 6	5½— 6	5⅝	...
50,000	Do. do. do. 4½ Mort. Deb. Stock...	Stock	4½%	...	...	111 —114	111 —114	...	...
50,000	India-Rubber, Gutta-Percha and Telegraph Works ...	10	10 %	10 %	...	21 — 22	21 — 22	21⅝	21½
800,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	100 —104	100 —104	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	3½%	3½%	...	9 5/16— 9 7/16	9⅜— 9½	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	...	13 — 13½	13 — 13½	...	...
37,350	Telegraph Construction and Maintenance	12	15 %	15 %	15 %	37 — 41	37 — 41	39	37⅝
150,000	Do. 4 % Deb. Bds. Nos. 1 to 1,500 Red. 1909 ...	100	...	...	...	102 —105	102 —105	...	...
20,000	Telegraph Manufacturing, Ord. Nos. 1 to 20,000 ...	5	...	...	...	9 — 10	9 — 10	...	...
20,000	Do. do. 5% Cm. Prf. Nos. 1 to 20,000 ...	5	...	...	...	5½— 6	5½— 6	...	...
540,000*l*	Waterloo and City Railway, Ord. Stock	100	...	3 %	3 %	101 —104	101 —104	103½	103

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

*Birmingham Electric Supply, Ordinary £5 (fully paid) 8—10.
Brompton and Kensington, 4½% Debentures of £100, 102—104.
National Electric Free Wiring, 10s. paid, 5s.—7s.
Oldham, Ashton, and Hyde Electric (£10 pd.), Ord., 18—19.
Do. do. Pref. (£10 pd.), 10½—11.
Smithfield Market Electric, 1½—2½.
Kensington and Knightsbridge Electric Lighting, Ordinary Shares £5 (fully paid) 12—13; 1st Preference Cumulative 6%, £5 (fully paid), 7½—7⅞. Debentures, 102—105. Dividend, 1899, on Ordinary Shares 11%.
Kidderminster and District Electric, Pref. (£6 pd.), 6—6½.
*T. Parker, £10 (fully paid), 18½.

* From Birmingham Share List.

Bank rate of discount 4 per cent. (January 25th, 1900).

MARKET QUOTATIONS, Wednesday, February 7th.

CHEMICALS, &c.	This week.	Last week.	Increase or Decrease.
a Acid, Hydrochloric .. .. per cwt.	5/-	5/-	..
a „ Nitric .. .. .. per cwt.	22/-	22/-	..
a „ Oxalic .. .. .. per cwt.	32/-	32/-	..
a „ Sulphuric .. .. .. per cwt.	5/6	5/6	..
a Ammoniac, Sal .. .. .. per cwt.	40/-	40/-	..
a Ammonia, Muriate (crystal) .. per ton	£29	£29	..
a „ „ .. .. per ton	£27	£27	..
a Bleaching powder .. .. per ton	£7	£7	..
a Bisulphide of Carbon .. .. per ton	£15	£15	..
a Borax .. .. per ton	£16 10	£16 10	..
a Benzole (90 %) .. .. .. per gal.	7/-	7/-	..
a „ (50/90 %) .. .. .. per gal.	5/6	5/6	..
a Copper Sulphate .. .. .. per ton	£24 10	£24 10	..
a Lead, Nitrate .. .. .. per ton	£25	£25	..
a „ White Sugar .. .. .. per ton	£31	£31	..
a „ Peroxide .. .. .. per ton	£27 10	£27 10	..
Methylated Spirit .. .. per gal.	2/9	2/9	..
Naphtha, Solvent (90 % at 160° C.) .. .. per gal.	5/6	5/6	..
a Potash, Bichromate, in casks.. per lb.	4½d.	4½d.	..
a „ Caustic (75/80 %) .. per ton	£24	£24	..
a „ Bisulphate .. .. per ton	£35	£35	..
a Shellac .. .. per cwt.	68/-	68/-	..
a Sulphate of Magnesia .. .. per ton	£4 10	£4 10	..
a Sulphur, Sublimed Flowers .. per ton	£6	£6	..
a „ Recovered .. .. per ton	£5 10	£5 10	..
a „ Lump .. .. .. per ton	£5	£5	..
a Soda, Caustic (white 70 %) .. per ton	£10 15	£10 15	..
Crystals .. .. .. per ton	£3	£3	..
a „ Bichromate, casks .. per lb.	3¾ l.	3¾d.	..
METALS, &c.			
Aluminium Wire, in ton lots .. per ton	£294	£294	..
b „ Sheet, in ton lots.. per ton	£191	£191	..
p Babbitt's metal ingots .. .. per ton	£80 to £140	£75 to £135	£5 inc.
c Brass (rolled metal 2" to 12") basis per lb.	8d.	8d.	..
c „ Tube (brazed) .. .. per lb.	10d.	10d.	..
c „ Wire, basis .. .. per lb.	8½d.	8½d.	..

METALS, &c. *(continued).*	This week.	Last week.	Inc. or Dec.
f Ebonite Rod .. .. .. per lb.	8/-	8/-	..
f „ Sheet .. .. .. per lb.	5/-	5/-	..
g Copper Bars .. .. .. per ton	£88	£82	£1 inc.
g „ Wire (basis price) .. per lb.	10½d.	10½d.	..
g „ Sheet .. .. .. per ton	£88	£82	£1 inc.
g „ Rod .. .. .. per ton	£83	£82	£1 inc.
n German Silver Wire .. .. per lb.	1/6	1/6	..
h Gutta-percha, fine .. .. per lb.	7/-	7/-	..
h India-rubber, Para fine .. per lb.	4/7 to 4/8	4/7 to 4/8	..
i Iron, Charcoal Sheets .. .. per ton	£18	£18	..
i „ Pig (Cleveland warrants) per ton	68/8	67/9	11d. inc.
i „ Forgings, according to size per ton	From £11	From £11	..
i „ Scrap, heavy .. .. per ton	70/- to 72/6	70/- to 72/6	..
i „ Wire galvanised No. 8 .. per ton	£14 5	£14 5	..
g Lead, English Ingot .. .. per ton	£16 10	£16 10	..
g „ „ Sheet .. .. per ton	£18	£18	..
m Manganin Wire No. 28.. .. per lb.	8/-	8/-	..
g Mercury .. .. .. per bottle	£9 12 6	£9 12	..
d Mica (in original cases), small per lb.	2d. to 8d.	2d. to 8d.	..
d „ „ „ medium per lb.	1/9 to 2/9	1/9 to 2/9	..
d „ „ „ large per lb.	3/6 to 7/6	3/6 to 7/6	..
p Phosphor Bronze, plain castings per lb.	1/1 to 1/4	1/1 to 1/4	..
p „ rolled bars & rods per lb.	1/1 to 1/4	1/1 to 1/4	..
p „ r'l'd str'p & sheet per lb.	From 1/2½	From 1/2½	..
o Platinum .. .. .. per oz.	£3 11	£3 11	..
p Silicium Bronze Wire .. .. per lb.	10½d. to 1/	10½d. to 1/	..
i Steel, Magnet, acc'd'g to desc'p'n p. ton	From £16	to £40	..
i Steel, Magnet, in bars	£58	£18	..
g Tin, block .. .. per ton	£136 10	£133	£3 10 inc.
g „ foil .. .. per lb.	nom. 1/9	nom. 1/9	..
n „ wire Nos. 1 to 18 .. .. per lb.	1/10	1/10	..
p White Anti-friction Metals—			
"White Ant" brand .. per ton	£40 to £70	£40 to £70	..
j Yarns, Cotton, Single 10lb. bundles pr lb.	7½d.	7½d.	..
j „ Best Flax, 6 lea. .. per lb.	5½d.	5½d.	..
j „ Hemp, 3 ply 10 lbs. .. per lb.	4d.	4d.	..
j „ Russian, 10 lbs. .. per lb.	4½d.	4½d.	..
j „ Jute, 180 lbs. rove .. per ton	£14 10	£14 10	..
k Zinc, Sheet (Vielle Montagne bnd.) p.t	£27 5 nett.	£26 5 nett.	£1 inc.

Quotations supplied by
a Messrs. G. Boor & Co.
b The British Aluminium Company, Ltd.
c Messrs. Thos. Bolton & Sons.
d Messrs. F. Wiggins & Sons
e

Quotations supplied by
f The India-Rubber, Gutta-Percha, and Telegraph Works Company, Ltd.
g Messrs. James & Shakspeare.
h Messrs. Jackson & Till.
i Messrs. Bolling & Lowe.
j Messrs. Henry C. Yee & Co.

Quotations supplied by
k Messrs. Morris Ashby, Limited.
m Messrs. W. T. Glover & Co., Ltd.
n Messrs. P. Ormiston & Sons.
o Messrs. Johnson, Matthey & Co., Ltd.
p The Phosphor Bronze Company, Ltd.

INSTITUTION OF ELECTRICAL ENGINEERS.

AN ELECTROLYTIC CENTRIFUGAL PROCESS FOR THE PRODUCTION OF COPPER TUBES.*

By Sherard Cowper-Coles, Member.

Introduction.

The electro-deposition of copper is now carried on in many large engineering works. Over one-third of the total copper output of the world is now electrolytically refined. Electrolytic refining has of late years made remarkable progress; most of the copper used by electrical engineers is refined electrolytically. The demand for electrolytic copper is on the increase, and the capacity of most of the electrolytic refining works has been, or is being, increased.

The world's total output of electrolytic copper 10 to 15 years ago, did not exceed 10 to 15 tons a week. In 1881 to 1882 this amount was, as a result of the refineries erected in Swansea, probably increased to about 60 tons. During the next four or five years several of the American refineries got to work, and by this time, say 1888 to 1890, the world's total production was probably not more than 280 to 300 tons per week. Since that date, up to the present time, many refineries of gigantic size have come into existence, not only in America, but in England, France, Germany, and even Japan, and it is quite safe to estimate the world's production at the present moment at no less than 500 tons per day, or about 180,000 tons of electrolytic copper per annum, and during the refining of this quantity of metal there will be not less than 20,000,000 ounces of silver and 100,000 ounces of gold recovered. This startling result has been achieved in a maximum of 25 to 30 years; this industry has had a growth probably unparalleled in the history of commercial enterprise.

Whereas formerly, currents of only 2 to 4 amperes per square foot were thought permissible, to-day current densities of from 15 to 20 amperes are said to be employed in some establishments, and the end is not yet in sight.

One of the best-known electrolytic processes for the manufacture of tubes is that in which an agate burnisher is used for consolidating the deposit during electro-deposition. This process has met with considerable success, the chief drawback being the tendency of the copper to laminate or exfoliate where the burnisher has been at work, the pressure on the burnisher requiring to be regulated to a great nicety. Elmore has sought to build up electro-deposited tubes equal to drawn ones by causing a burnisher to constantly traverse the length of the tubes backwards and forwards, as they slowly rotate in the bath, and thus yield a copper possessing a high density. The current density originally employed for this process was about 16 amperes per square foot, but this the author believes has been considerably increased. Copper deposited by the Elmore process has stood a stress of 26·5 tons per square inch, with an extension of 16·5 per cent, the limit of elasticity being reached with a load of 23·3 tons per square inch, the specific gravity of the metal being as high as 9·2. Von Hübl has succeeded in producing, by simple deposition without the aid of a burnisher, a specimen of copper which broke at a stress of 23·6 tons—commercial cast copper breaks at about 19,100 lbs. = 8·4 tons per square inch. Another process that is now being operated on a large commercial scale, substitutes a sheepskin burnisher for an agate one, smooth deposits being obtained by the application of an insulating coating to the inequalities on the surface. The sheepskin impregnators, which move over the surface of the metal, coat all projecting parts with a thin film of animal fat, which hinders further deposition until the surrounding depressions have been raised to the common level. In later patents impregnators are mentioned composed of organic gelatinous or albuminous matter free from excess of grease, rendered insoluble by treatment with bichromate, such as a 5 per cent. solution of potassium bichromate, or the softening of the albuminous or gelatinous constituents of the impregnators is prevented by soaking them with a solution of formic-aldehyde (within the limits of 10 per cent. and 40 per cent.), after which it is washed in water to remove the aldehyde, or this substance is neutralised or decomposed by means of sulphuric acid. It is claimed for impregnators so treated that they may be employed with equal facility in a hot or cold bath. The current used is from 35 to 40 amperes per square foot of cathode area, the voltage required is about 1·6 per vat. Tubes are deposited 12 feet in length and 16-inch diameter, and ⅛ in. thick, which are cut longitudinally and opened to form sheets. Several investigators have patented methods to improve the physical properties of electro-deposited copper by injecting the electrolyte on to the copper during deposition. Craydon Poore has devised a method for producing plates by projecting the electrolyte forcibly on to a cathode placed in a horizontal position.

The author has lately developed a centrifugal process, which is now being worked on a practical scale, for copper refining and the manufacture of copper tubes, sheet and wire by electro-deposition, which does away with the troubles of lamination and enables a much higher current density to be used than has hitherto been the case, smooth tubes having been produced 12 inches in diameter at the remarkably high current density of 190 amperes per square foot, the voltage being from 1—1·2. Solid drawn copper tubes of such diameters cost about three times the price of tough copper cake. The centrifugal process is distinct from those already referred to, inasmuch as there are no burnishing tools employed, but the cathode on which the copper is deposited is revolved at a high rate of speed, the result being that the skin friction, between the deposited metal and the electrolyte, keeps the copper beautifully smooth and compact. Any gas bubbles evolved at the cathode, or impurities in mechanical suspension in the electrolyte which would have a tendency to settle on the cathode, are thrown off by centrifugal force. Mr. J. W. Swan has found that regularity and smoothness of deposit were almost entirely dependent on the absence of solid particles held in suspension in the electrolyte, and that excrescences could be entirely avoided by taking care that the electrolyte was free from solid floating particles. He observed that at the seat of each "nodule" was a speck of some foreign substance. Dr. G. Gore has given the matter some thought, and has observed that the greatest length of "nodule" is in the direction of the greatest intensity of current and amount of copper in solution. On the table are a number of specimens of tubes and sheets produced by this process, some at a current density of 200 amperes per square foot, which were deposited from solutions of approximately the following composition; the copper anodes containing about 30 ozs. of silver to the ton:—

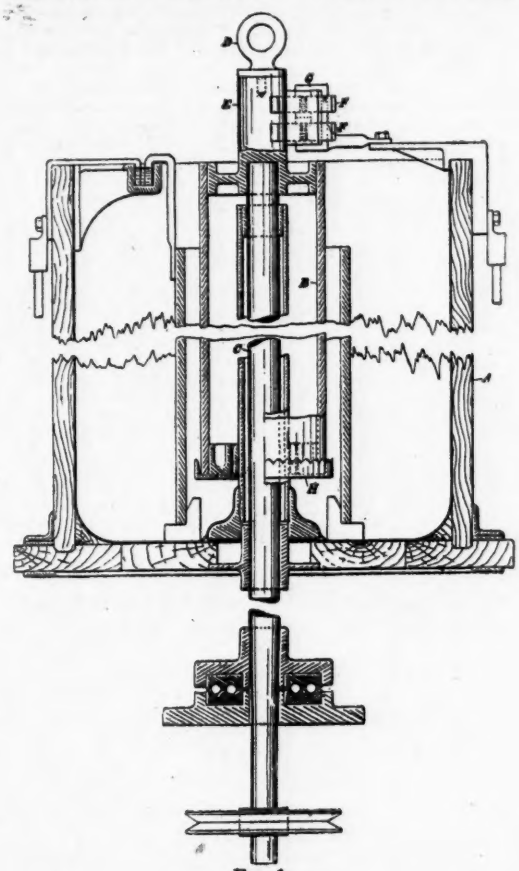


Fig. 1.

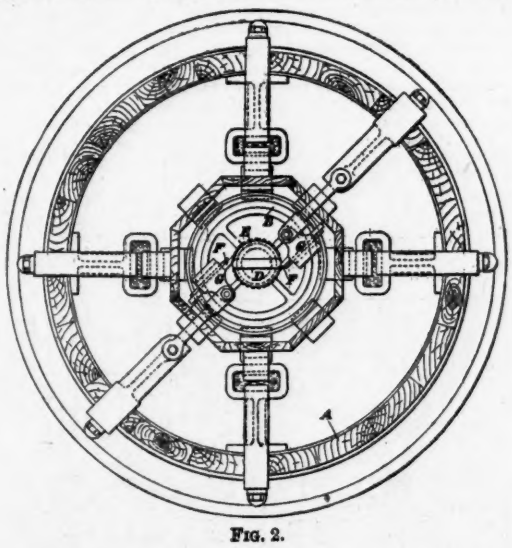


Fig. 2.

* Abstract of paper read January 25th.

	Ozs. per gal.	Percentage.
Copper sulphate ($CuSO_4 5H_2O$) ...	... 22 44	10 95
Sulphuric acid (H_2SO_4) ...	... 22 34	10·90
Ferrous sulphate ($2FeSO_4$) ...	... ·05	·02
Water	... 160·00	78·13
		100·00

The apparatus employed for the centrifugal process consists of a wooden vat, A, figs. 1 and 2, in which are placed anodes composed of crude copper. The cathode is a hollow mandrel, B, made of brass, which is supported on a revolving shaft, C. The shaft is brought through the bottom of the vat to the top of the cell, and is protected from the acid copper sulphate solution by a lead-cased wrought-iron column. The shaft is caused to revolve by gearing placed beneath the depositing cell, the speed varying with the size of the mandrel employed. The mandrel at one end is fitted with an eye bolt, D, for lifting purposes, and a circular brass casting, E, against which the contact brushes, F, rub for collecting the negative current. The

Fig. 3.

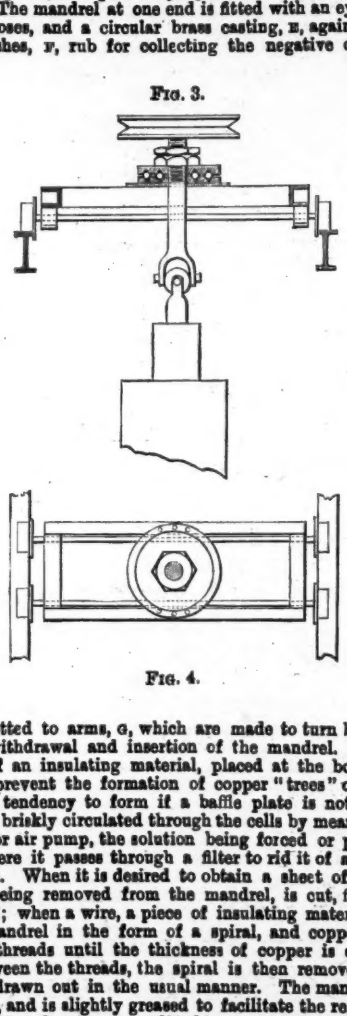


Fig. 4.

brushes are fitted to arms, G, which are made to turn back to allow of the easy withdrawal and insertion of the mandrel. H is a baffle plate made of an insulating material, placed at the bottom of the mandrel to prevent the formation of copper "trees" or "nodules" which have a tendency to form if a baffle plate is not used. The electrolyte is briskly circulated through the cells by means of an acid proof pump or air pump, the solution being forced or pumped to a reservoir, where it passes through a filter to rid it of all impurities in suspension. When it is desired to obtain a sheet of copper, the tube, after being removed from the mandrel, is cut, flattened out, and annealed; when a wire, a piece of insulating material is wound round the mandrel in the form of a spiral, and copper deposited between the threads until the thickness of copper is equal to the distance between the threads, the spiral is then removed, and after annealing is drawn out in the usual manner. The mandrel is given a small taper, and is slightly greased to facilitate the removal of the tubes. Figs. 3 and 4 show a modified arrangement for driving the mandrel above, instead of from below. Another interesting feature of the centrifugal process is that it enables a hot and more acid solution to be used than is generally employed. The amount of free acid has a very marked effect upon the voltage required, but a very small effect upon the actual weight of copper obtained, compared with the theoretical, as shown by the following table; the amount of copper sulphate was 32 ounces per gallon of water = 16·66 per cent.

Table I.

No.	Current density.	Solution—cold. Voltage.	Solution—cold. Ounces of H_2SO_4 per gallon by weight.	Percentage of free acid by weight.	Peripheral speed. Feet per minute.
1	100	3·5	0	0	471
2	100	2·5	6	3·03	471
3	100	·20	8	4·00	523
4	100	1·8	10	4·95	471
5	100	2·2	25	11·52	523
6	100	8·0	30	13·51	523
7	100	12·0	40	17·24	471
8	100	14·0	60	23·81	523
9	100	20·0	100	34·24	628

The solution was circulated at such a rate that it was renewed in the depositing cell every five minutes. The above table shows the advantage of increasing the acidity of the solution up to a certain point, and the disadvantage of increasing it beyond that point; the critical point seems to be about 15 ounces of free sulphuric acid per gallon = 14·71 per cent. [? 7 3 Eds.] The rise of voltage in a cold solution is explained by the fact that the addition of sulphuric acid to a copper sulphate solution causes the copper sulphate to crystallise out; this takes place on the electrodes, and largely increases the resistance. It has been shown that a saturated copper sulphate is the best conductor; E. Koller has observed that a 25 per cent. solution of sulphuric acid offers the best resistance. With too much acid the polarisation ensues from its own decomposition by the action of the current. The latter trouble is said to set in when the copper sulphate solution has reached an acidity of about 13 per cent.; these remarks apply to stationary anodes.

The following table gives the voltage required when depositing at 100 amperes per square foot from a solution containing 32 ounces copper sulphate per gallon = 16·66 per cent., the temperature being 160° F., various amounts of free acid being used, the anodes being of commercial copper.

Table II.

No.	Current density.	Voltage.	Ounces of H_2SO_4 per gallon by weight.	Percentage of free acid by weight.	Peripheral speed. Feet per minute.
1	100	3·5	0	0	500
2	100	1·3	10	4·95	500
3	100	0·9	20	9·43	500
4	100	0·8	30	13·51	500
5	100	0·75	40	17·24	500
6	100	0·75	50	20·66	500
7	100	0·7	60	23·81	500
8	100	0·7	100	34·24	500

The solution in this experiment was not circulated. Comparing this table with No. I. the advantage of using a hot solution is shown, also the advantage of increasing the acidity.

The following Table III. gives the variation of current and voltage due to the temperature of the electrolyte.

Table III.

Amperes.	Volts.	Temperature of solution.
0·55	8·0	60° F.
4·00	7·0	70° "
8·00	5·0	75° "
10·00	4·0	78° "
14·00	2·0	82° "
16·00	1·0	90° "
16·00	0·85	100° "
16·00	0·80	120° "
16·00	0·75	140° "
16·00	0·70	180° "
16·00	0·70	200° "

This table shows how a hot solution allows a heavier current to pass at a much lower voltage; 150° F. is probably the most economical temperature to work at. The curve on the diagram was arrived at by dividing the E.M.F. by the current, giving the resistance in ohms.

It is well known that from a neutral or slightly basic solution copper comes down in a coarse-grained brittle condition, whereas the amount of free acid has a very marked effect on the voltage, as is shown by Table II. This may be due to the production of a small amount of cuprous acid from a neutral or basic solution, or the influence of a large percentage of free acid on the mode of crystallisation of the metal.

Von Hübl has observed that the dark coloured spongy deposits produced by too high a current density occur the more readily the poorer the electrolyte round the cathode in copper. According to the same authority this dark deposit is not due to the presence of cuprous oxide, but to the formation of a hydride. Hydrogen may under certain circumstances be occluded by electrolytic copper, which has been proved by the analyses which have been made of the gas pumped out of various specimens of the metal. Thus, a certain sample gave up 4·4 times its volume of gas, consisting of 77·3 per cent. of hydrogen, 8·4 per cent. of carbon monoxide, 11·1 per cent. of carbon dioxide, and 3·2 per cent. of water vapour. Foerster and Liedel have studied the influence of temperature on the character of copper deposited from acid solutions. The experiments were not very conclusive, but they tend to show that tougher copper is obtained with hot solutions than with cold. The experiments of Foerster and Liedel also show that the precipitation of brownish red powdery copper is connected with a certain low concentration of the copper ions in solution. Due to the rapid revolving of the cathode in the centrifugal process, the solution is kept well mixed, so the difficulty of having the solution poor in metal round the cathode is overcome.

The experiments on the loss of copper by corrosion with a revolving mandrel are not very reliable, but there is no apparent reason why the loss should differ from that with a stationary mandrel. If the solution is kept thoroughly saturated with copper sulphate, the corrosion ought not to be more than a very small per cent. of the

total copper deposited. This loss might be reduced by using a higher current density; for instance, if the current was doubled the percentage loss would be halved.

As already mentioned, a very high current density can be used with the centrifugal process, and smooth deposits can be obtained with a current density of even 200 amperes per square foot. This is a matter of great importance, as in copper refining with high current densities less anode sludge is formed. It has been observed by Foerster and Liedel that when a high current density and a high temperature are used there is far less sludge formed on the anodes. With a current density of 0·3 ampere per square decimetre at the ordinary temperature, a weight of 0·5 kg. of anode copper consumed left 3·7 grms. of sludge, containing 60 to 70 per. cent. of copper, partly as cuprous oxide. Under the same conditions, but working at 40° C., the sludge was only 1·2 grms., and was nearly free from copper. With a higher current density, viz., 1 ampere per square decimetre, the quantity of anode sludge was about the same at 20° C. and 40° C., viz., 2·5 grms. from 1 kg. of copper. These results, although far from exhaustive, go to show that the high current densities used in modern copper refining have the incidental advantage of reducing the quantity of anode sludge, and thus making the working up for silver and gold easier and more economical. A yet higher temperature, viz., 60° C., increases the quantity of sludge; a good deal of the increase is due to the presence of metallic copper, which may be regarded as having been formed during the spontaneous resolution of cuprous sulphate, momentarily produced at the anode, thus:—

$$Cu_2 So_4 \; Cu \; So_4 \; Cu,$$

Gold is not dissolved from the anode, and silver only to a small extent, and selenium and tellurium not to any appreciable extent when present in small quantities.

Arsenic is found to be more readily soluble, and bismuth the least soluble, amongst the impurities in the anodes. According to Dr. Borcher, the mud or slime deposited on the anode may contain, after drying, gold, platinum, silver, silver sulphide, cuprous oxide and sulphide, basic sulphates of bismuth, tin and antimony, antimonic acid, arseniate of copper, metallic arseniates and antimoniates, lead sulphate and slag constituents in which may be iron, lime, magnesia, and silica, and with these there will also be a certain amount of metallic copper in a pulverulent state. If the anode contains too high a percentage of impurity, it leads to several practical difficulties such as the periodical scrubbing of the anodes. Some of the impurities found in electrolytic copper are electrolytically deposited from the electrolyte, and others are mechanically thrown down. Centrifugal action seems to prevent any matter in suspension settling on the rapidly revolving cathode.

Copper prepared by electrolysis may have as low a density as 8·00; the figure for normal copper is 8·9. Hard rolling, cold hammering, and hard drawing increase the tensile strength, and limit the elasticity of copper considerably. The extensibility of annealed copper becomes less at high temperatures, and that of mechanically worked copper becomes higher. Some copper sheet (not annealed) deposited by the centrifugal process, ·0245 in thickness, broke at 433 lbs., which is equal to 22·1 tons per square inch. Hard-drawn wire made by this process has a tensile strength of 29 tons per square inch, annealed 20 tons, the electrical conductivity being 99 per cent. The author has obtained excellent tough deposits of copper with the theoretical yield from a solution composed of:—

	Ozs. per gallon.	Percentage by weight.
Copper sulphate ($Cu\,So_4 + 5\,H_2O$)	32	14·87
Sulphuric acid (H_2SO_4)	12·6	10·77
Water		74·36
		100·00

S. Sheldon has carried out a number of experiments to determine the electric conductivity of copper when annealed at various temperatures. A sample of copper was drawn several times without annealing, so as to become very hard, and was then cut up into different lengths which were separately annealed at different temperatures both in a vacuum and in hydrogen, and tested for conductivity. The effect of the different annealings in relation to conductivity is shown by the following figures:—

Annealed in a vacuum.		Annealed in hydrogen.	
Annealing temperature.	Conductivity.	Annealing temperature.	Conductivity.
°C.	Per cent.	°C.	Per cent.
20	101·5	20	99·0
37	101·5	45	99·0
54	101·5	105	99·3
118	101·6	234	99·8
215	102·0	360	101·0
300	102·1	413	101·9
600	102·4	1,050	389·33
755	102·7	—	—
930	99·0	—	—

According to Dr. Kiliani, the back E.M.F. is 0·12 volt, which has to be overcome with each pair of electrodes in the electrolyte under normal conditions. This back E.M.F. is due to the polarisation at the surface of the anode, and increases with the impurity of the raw copper used.

The following figures give the approximate cost of producing electrical energy on a large scale with condensing engines, the cost per kilowatt-hour working out to ·3995, in which case the cost of the electrical energy required to deposit one ton of copper is 14s. 5d. A large installation of 10,000 H.P. is now being put up near Manchester which will supply electricity at ½d. per kilowatt-hour:—

Estimated Cost of working a 2,100-kw. Plant, the Price being based on that prevailing in England.

(Staff arranged in three shifts for continuous running of 150 hours per week.)

	£ s. d.	£ s. d.
Stokers	6 at 1 13 3 per week	9 0 0
Trimmers	3 „ 1 4 6 „	3 13 6
Engine drivers	6 „ 1 17 6 „	11 5 0
Oilers	12 „ 1 8 0 „	16 16 0
Dynamos and switchboard hands ...	6 „ 1 8 0 „	8 8 0
Superintendent... ...	1 „ 4 0 0 „	4 0 0
Total wages per week		£53 2 6

(At 150 hours = 7s. 1d. per hour).

PER KW.-HOUR.

	Pence.
Salaries and wages	·0405
Coal, 2·4 lbs. at 16s. per ton	·2050
Water, at 6d. per 1,000 gallons	·0014
Oil and sundry stores, waste, &c.	0400
Standing charges, office expenses, rent, insurance &c.	·0300
Repairs	·0100
Interest on capital, £29,000 at 5 per cent.	·0222*
Interest on buildings, £5,000 at 5 per cent. ...	·0038*
Depreciation on plant, 10 per cent.	·0443*
Depreciation on buildings, 3 per cent.	·0023*
Total cost per unit generated	0·3995d.

* On basis of working 50 weeks in the year.

The Anaconda Mining Company has recently made public the cost of electrolytic refining during the year 1897 to 1898 at its works at Anaconda, Montana; the figures given are as follows:—

	£ s. d.
Assay expenses and salaries	3,062 7 8½
Electric light	475 11 11
Expenses	775 16 2
Labour	28,408 13 2
Legal expenses...	426 7 1
Power house expenses, coal	27,589 0 8½
„ „ labour	9,880 9 10
„ „ machinery and repairs	4,020 19 7

Making a total of £42,812 6s. 6d. for power, of which £1,250 was charged to a silver mill, leaving a net expense of £41,562 6s. 6d. for power for the electrolytic refinery.

	£ s. d.
For recasting scrap anodes	3,685 4 8
Regenerating plant expenses	2,460 5 9½
Salaries, including management	3,252 9 11½
Stable expenses	391 17 6
Sundry supplies	2,362 6 6
Switching product	181 5 0
Taxes	1,146 19 3
Repairs on buildings	1,076 8 5
„ on machinery	1,521 0 11
On refining tanks	1,659 2 1½
Making a total of	£92,398 7 11½

The output of electrolytic copper was 59,505,711 lbs., consequently the cost of production was 3s. 1½d. per cwt. or £3 2s. 6d. per ton.

In the above calculations the dollar was taken at 4s. 2d.

RECEIVER DROP IN MULTIPLE EXPANSION ENGINES.

The experimental engines at the College of Science, Newcastle-on-Tyne, are in the hands of Prof. Weighton, who, from time to time, has published interesting information relative to the tests he has made of these engines. On January 19th he read a paper before the North-East Coast Institution of Engineers, dealing with his more recent tests, and very copiously illustrated by some excellent diagrams. It is, of course, difficult to say that tests made with an experimental engine, or, indeed, with any engine, can be held to prove that the results obtained can be rigidly applied to any engine in practice. But when certain facts are seen to hold good through a series of experiments in which one factor is varied, a general idea can be formed as to the influence of such factor. Doubtless it would be wrong to apply the teachings of any series of experiments so far as these point to a certain cut-off in any one cylinder that shall give maximum economy, but whatever may be shown by any one engine, it is probable that other engines would not show very widely divergent results. The present trials were made with the object of determining the most economical point of cut-off in the larger cylinders of multiple expansion—by which the author means multi-cylinder compound engines, that is to say, in the low pressure cylinder of ordinary, or as they are now conventionally termed, compound engines, and in

the intermediate and low pressure cylinders of triple engines; in fact, of any engine in all the cylinders except the first. In the early days of compound engines, which sometimes consisted of a high pressure cylinder added to an old engine that already possessed automatic cut-off gear, as, for example, when an old beam engine was McNaughted, it was usual to throw the cut-off gear of the old cylinder out of gear, whereby the low pressure cylinder was made to take steam from the receiver for probably three-fourths or seven-eighths of the stroke. But it was found that when the low pressure cylinder was allowed to run with its own automatic expansion gear, an economy was secured, as we can very well understand, for it has long been demonstrated that the Woolf system of treating engines is erroneous. From this discovery, if it can be called one, there have sprung up three methods of construction. By one method, the low pressure cylinder has been fitted with the fullest expansion gear automatically variable, and the cut-off has, so to speak, kept in parallel with that in the high pressure cylinder. We have seen such automatic variable gear fitted to the engines of large cotton mills, in which the power throughout the year never varied many horse-power, and on which even variable expansion gear to the high pressure cylinder was supererogatory, at least so far as automatic variability is concerned. The second system of construction recognised in a measure the unnecessary complication and expense of the preceding system, and was content to apply automatic action to the first cylinder alone, leaving the low pressure valves still as before, but with a cut-off gear adjustable by hand, the idea being that when set to work, the best point of cut-off would be found in a few months, and no further alteration would be found necessary so long as the load was maintained uniform. The third and probably most economical method for steady loads employed plain gear for the low pressure cylinder, the cut-off of which was fixed once for all by the designer at or about half stroke, and automatic expansion was still preserved to the high-pressure cylinder. Opinion, as represented by the influence of the superstitions that had gathered round the whole question of automaticity, still demanded, even for engines with uniform load, a variable rate of expansion to the first cylinder. Such slight variations in load as might take place could well have been dealt with by throttling with little or no loss economically.

Certain of the older school of engine makers, recognising that rapid variation of cut-off was unnecessary, provided throttle valves to regulate for instantaneous changes and slowly variable automatic gear which continued to move until the engine came to its normal speed. In this manner the engine governor was gradually brought back to the speed at which the throttle valve was normal in opening. For engines of very variable loading all these things have become matters almost of past history, but are worth remembering. As regards the best point of low pressure cut-off, the writer is unaware of any experimental effort to discover this. Experience, we may say, has fixed on about $\frac{7}{16}$th of the stroke as an economical point, and the author soon found that the matter was one of some importance, as the present writer has always understood it had been found in the early days as above described. The author has re-discovered the fact, and, what is new, has tried to determine the details. The engine experimented with has cylinders 7, 15½, and 23 inches diameter, the stroke of all being 18 inches.

In the first trials the intermediate cut-off was varied; in the second series, of six as in the former case, the low pressure cut-off was the item varied. The water consumption per hour lies in a straight line on the diagram, and increases slowly as the low pressure cut-off is made later, and very considerably when it is the intermediate cut-off that is varied. In the first case the total water consumption is 2,070 lbs., with a cut-off at 6·4 inches of the low pressure cylinder, and is less than 2,100 when the cut-off is at 14 inches, whereas with variable cut-off in the high pressure cylinder a consumption of 2,050 at 5½ inches cut-off grows to 2,250 at 13⅜ inches.

This points out that the application of variable or any other expansion gear is more important in the earlier cylinders. When steam was in all three jackets, the total water consumption line, though straight, was horizontal at a little over 2,050 lbs. For the given water consumption the line of brake horse-power rises in a gentle curve to a maximum and then falls gently down again. The diagram shows that the maximum economy cut-off is for the high pressure cylinder at 6⅜ inches, for the low pressure at 10½ inches, or about $\frac{9}{16}$ths of the stroke.

As the engines in question have also a 10½ cylinder, the tests could be made with variable cylinder ratios, and in all a large number of trials were made, and it was found that the total number of expansions of the steam in passing through the engine had no effect upon the point of maximum economy cut-off in the final cylinder; that is to say, a variation in the high pressure cut-off must not be allowed to vary the cut-off in the final cylinder. This, of course, confirms the general experience of practical men that the low pressure cut-off may be fixed at about one-half.

Curiously enough, neither has the boiler pressure any influence upon the point of maximum cut-off in the final cylinder. Steam jackets also appear to have no serious effect upon the point of cut-off, though it is to be noted that later cut-off is not possible. With the jackets in action, the variation was from 5⅜ inches to 6⅜, the latter being the point for no jackets.

Similarly there is no material effect when the receiver capacity is varied.

With a compound engine and cylinder ratio, 11, the maximum cut off for economy was as early as 4⅜ inches in the large cylinders. Cylinder ratios in these tests were chosen as varied as possible, for cylinder ratio was suspected to have a considerable influence, and so far as it was possible to judge from the trials, it appears that the one and only material factor in determining the cut-off point in any cylinder following the first is the ratio between the cylinder in question and that immediately preceding it. In the annexed table is given in the first column the ratio of cylinders, in the second the number of inches at which best cut-off occurs (in a stroke of 18 inches), and in the third column the cylinder ratio multiplied by the quotient of the best cut-off divided by the whole stroke. The figures in Column III. are thus proportionate to the receiver drop with which is associated maximum economy:—

I. Any cylinder capacity. / Precedent cylinder capacity = R.	II. Best cut-off in inches of stroke.	III. R × Best cut-off / Stroke.
2·195	10¼	1·28
2·195	10⅜	1·31
2·295	10	1·275
2·296	11	1·4
4·86	6⅜	1·72
5·04	6⅜	1·85
11·00	4⅜	2·67

The values in Col. III when plotted to a base of R, lie practically on a straight line. The equation to this straight line has been found to be as follows:—

$$R \times \frac{\text{Best cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6},$$

whence the best cut-off in terms of the cylinder ratio R is

$$\frac{\text{Best cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6\,R}$$

which equation plotted as a curve may be employed in design. This diagram is given together with the curve of cut-off for no receiver drop or that system of working which aims to bottle up steam in the receiver in order to increase the back pressure on the first cylinder, and raise that in the second cylinder, so that the high presure diagram expansion line ends at the same pressure as the exhaust line commences. The author goes on to state that late cut-offs are favourable to handiness as well as to smooth running. If this be so, then we might expect to find cylinder ratios of fair magnitude, *i.e.*, with a fairly small high pressure cylinder, carrying steam well along the stroke and late cut-off in the succeeding cylinders.

In the above table the values of R include clearance volumes.

Constructively also, owing to the smallness of valve travel ratio to port opening, the late cut-off is claimed to be advantageous.

Summing up, the author declares that for smooth working, durability, and economy, in so far as affected by receiver drop, that engine will be best which has small cylinder ratios, or at least ratios not exceeding certain limits.

It must be borne in mind that Prof. Weighton is a good deal tinged probably by marine influences, but his conclusions seem to be quite suitable for the variable loads of electrical traction or other power purposes for which it is necessary that the first cylinder of a compound engine ought to be of considerable size in order that maximum loads may be dealt with. Finally, assuming that the figures found for the experimental engine are of general applicability, we have, to repeat

$$\frac{\text{Cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6\,R}.$$

The coefficient 6·6 is, perhaps, variable for different engines, and not applicable all round.

As regards the low pressure cylinder of triple engines and the second intermediate and low pressure cylinders of quadruple engines, the maximum *economy* cut-off in these cylinders coincides with the maximum *power* cut-off. As regards the second cylinder of triples and quadruples, the maximum *power* cut-off is later considerably than the maximum *economy* cut-off, but in compound engines the maximum *power* cut-off is but little later than the maximum *economy* cut-off.

An important point is that where cylinder ratios are small, or, say, R = 2 to 2·5, a considerable variation of the low pressure cut-off may be made without appreciable fall in economy. This cannot be done when R is large. Further, as already stated, small cylinder ratio promotes handiness, uniformity, and smoothness in working, general durability, and compactness of design. Small cylinder ratio, of course, implies a considerable range of expansion in the first cylinder, and this is not an undesirable feature. It is both theoretically and practically an error to make of the first cylinder a mere measuring pot to cut off so much steam, and pass it forward to the next cylinder. Prof. Weighton is to be congratulated on these tests, and his very interesting paper and diagrams. We may perhaps question the reduction of the results to so hard and fast a formula. Before this can be accepted, the same, or some of the tests need to be made on some entirely different engine. But the coincidences shown by the tests are probably sufficiently marked to warrant the general conclusions as to the fixity of the point of cut-off in the larger cylinders of multi-cylinder engines.

A most important statement is that of the author's, that no particular influence on economy could be traced either to the proportion of power exerted by the several cylinders of compound engines, or even by the temperature ranges in the several cylinders. It is clear that as there are reasons in favour of both large and small first cylinders, the happy mean is likely to give best all-round results.

W. H. B.

THE THEORY OF THE VOLTAIC CELL.*

VOLTA'S fundamental principle may be enunciated thus. The values of the electrical potentials in two bodies of different kinds in contact with one another differ by a quantity which depends only on the natures of the two bodies, each of which is supposed to be uniform, and at the same temperature throughout.

In metals and other conductors of the first class † this difference of potential, or electromotive force of contact, obeys the laws of Volta, which may be enunciated as follows:—(*a*) The difference between the potentials of two conductors is the same whether they touch directly, or whether they communicate through a series of conductors of the first class, which series may be arranged in any way. (*b*) A closed circuit formed of conductors of the first class is in electrical equilibrium, and no current is maintained ‡ (*c*) The electromotive force of contact between two conductors is equal to the difference between the electromotive forces of contact found by placing them separately in contact with any third conductor.

In virtue of this last law, the consequences of Volta's fundamental principle do not conflict with that of the conservation of energy. An assertion to the contrary could only arise from neglect to take account of the work done in bringing the two metals to their actual conditions from the state in which their particles are at the minimum reciprocal distances.

Volta always applied his principle to conductors of the second class, but the production of a current in a cell with a closed circuit shows that they do not obey the laws enunciated above. Volta thought that his experiments justified his treating the electromotive force between a pair of conductors of the first and second class respectively, as well as that between a pair of the second class, as being so small in comparison with that between a pair of the first class that for a first approximation one might neglect the former and take account only of the latter. Those who adopted his ideas of the action of the pile went beyond him in this point, and treating the first two electromotive forces as actually *nil*, looked on every electrolyte as a simple conductor capable of bringing to the same potential any two metals between which it formed a communication. Consequently, every discussion between those who accepted the contact theory and the supporters of the chemical theory of the voltaic cell turned, firstly, on the reality of the difference between the potentials of two metals in contact, and, secondly, given its existence on its being sufficient to explain perfectly the effects of the voltaic cell.

Since on cutting the wire which connects the two plates of a voltaic couple, thus opening the circuit, the two ends of the wire are at different potentials; and since the potential is then constant throughout each of the plates which composes the couple, one must conclude that a sharply defined change of potential exists at the junction of the two metals, and if not over the whole contact surface, at least over part of it. But if it could be shown that this variation of potential does not occur at the junction of the two metals, it would be necessary to admit that an electromotive force exists at one or both of the contacts between metal and liquid. On the other hand, one can contruct an active voltaic cell, as Volta knew, with one metal and two liquids just as well as with two metals and one liquid. In that case the existence of an electromotive force is required either where a metal touches a liquid, or where two liquids are in contact. Of the three possible kinds of junction, metal to metal, liquid to liquid, and metal to liquid, two, at least, exist in every voltaic cell, and in the common cells, which have two liquids, all three are found. It is impossible, then, to assert, so far as these experiments go, that the seat of the electromotive force lies in a junction of one kind or of another.

Any doubt that electromotive force exists at all three kinds of junction seems to be removed by the experiments in which different physicists have shown that Volta's laws do not apply to circuits composed of electrolytes alone. Suppose, for instance, that four electrolytes are arranged in a series, the first and last being the same as one another and different from each of the intermediate ones. Then the potentials of the first and last are generally found to be different. This result seems to prove the existence of an electromotive force between two liquids in contact.

While, however, the existence of electromotive force at the junctions of two liquids in contact is proved by such experiments as the above, it is uncertain what view to take of the other two kinds of contact unless we can obtain the assistance of more decisive experiments.

In the meantime we may admit Volta's principle as generally correct, and suppose that a difference of potential exists on the two sides of every junction of two different conductors, but an explanation is still required of the mode in which this difference arises. It may be observed that the mechanism to which it is due is likely to be different according as one, at least, of the bodies is a liquid, or they are both metals. It would seem, in fact, that in the first case the electromotive force of contact is an electro-chemical phenomenon, while in the second case the field of hypotheses is less limited.

By the so-called contact theory electromotive force exists only at the junction of two metals, taking into account the electrolysis which takes place in the liquid of every cell. Volta thought that he had demonstrated the existence of this electromotive force, and his successors who have supported the contact, as against the chemical theory, have always thought the value of the electromotive force of contact between two metals to be sufficient of itself to explain fully the effects of the cell. Volta's investigation of this point can be reduced to two fundamental experiments. In the first of these a zinc-copper couple is held in the fingers by the zinc part, and while one plate of a condenser electrometer is touched with the copper, the other plate is touched with a finger. On (*removing the couple and*) lifting the upper plate, the leaves of the electrometer diverge. The employment of a moist hand reduces this experiment to the determination of the difference between the potentials of a voltaic cell formed by the zinc, the moisture of the fingers, and the metal plate of the condenser. This experiment does not furnish, nor does any other in which an electrolyte takes part, the desired proof of the existence of an electromotive force at a metallic junction.

In the second typical experiment the two plates of the condenser are of different metals, and are unvarnished. One of these is laid upon the other and then removed; or they may be connected by a wire when separated by a certain small distance, the connection broken, and the upper plate removed. In both cases the electrometer connected to one of these shows a deflection which, other things being equal, is proportional to the electromotive force of contact between the two metals. It is clear that no conductor of the second class enters into this action, and for a long time experiments of this type were considered to demonstrate the existence of electromotive force at the junction of two metals.

Those, however, who maintained the chemical theory of the pile, and denied the existence of electromotive force at the junction of two metals, refused to allow any weight to this experiment, and attributed the action to oxidation by the surrounding atmosphere. But there was little difficulty in meeting this objection (which, moreover, seemed vague and far-fetched) by showing that the result is not substantially modified by protecting from the action of the air the most oxidisable of the two metals, which, in the case of the common zinc, copper couple is the zinc. One way, for example, of doing this was to enclose the zinc in an insulating sheath, through which three short copper studs, perpendicular to the surface, served to make connection with the copper plate.

They sought still further to exclude the oxygen by substituting a different gas for the air, and conducting the experiment in a closed vessel. But this made no change in the contact difference of potential, except in those cases in which the gaseous medium acted chemically on the surface of one or both discs so as to produce an obvious change in appearance; and as only the nature of the superficial strata of the discs influences the result, so these variations of the electromotive force of contact were naturally explained. The same results were obtained when the experiment was performed, not as by Volta by separating the discs after a momentary contact, one being connected permanently to the electrometer, but by keeping them fixed and allowing the ultra-violet rays to fall on them in a suitable way. In fact, even in an atmosphere of nitrogen rarefied to the highest degree now possible, the result of Volta's fundamental experiment seems to be unchanged.

A new and very ingenious objection was raised much later against Volta's second fundamental experiment. It is supposed that a stratum of gas adheres to each metal, and that the deflection of the electrometer is due, not to an electromotive force of contact between the two discs, which might be suppose to be null, but to a difference between the potentials of the two strata; and that this difference is that which would exist between the poles of a voltaic cell formed of the two metals with an electrolyte consisting of the substance of the adhering strata. In fact, representing by the symbol (A B), the difference of potential between two bodies, A and B, and calling Z, C, the two metals, and S the enclosing strata, one meets on proceeding from the stratum adhering to Z to that adhering to C through the metallic junction between Z and C, the successive changes of potential (S Z) (Z C) (C S), and between the potentials of the two strata there will be a difference (S Z) + (Z C) + (C S), equal to that of a couple formed of the bodies, C S Z.

Although satisfactory experiments are still wanting to show the influence of the surrounding medium, this explanation of the second of Volta's principal experiments is in much favour. It may be remarked, however, that even if this explanation could be shown to be entirely in accordance with facts, still it would not follow that (Z C) must be zero. Indeed, the following observations may be made:—

First of all, if the gaseous strata adhering to the metals are insulators, and it is incomprehensible that they can be looked upon as conductors, the deflection of the electrometer will depend in some complex way on the distribution of charges on the gaseous strata and on the two metallic discs; and in any case the explanation must be correspondingly modified. In the second place, since the resultant electromotive force (S Z) + (Z C) + (C S) differs from zero, S behaves like an electrolyte, and is not subject to the laws of Volta. Now the experiment succeeds in a simple gas, such as hydrogen, and it seemed difficult to suppose that such a body can be susceptible of electrolysis. This objection has recently lost much of its weight, since now the possibility of the division of the molecules of all gases into free ions is generally admitted for the purpose of explaining the phenomena of the charges in gases, and the electrical phenomena of ordinary radiation and of Röntgen's rays.

It is clear that we do not possess sufficient arguments or facts to decide either for or against the application of Volta's principle to metals, and if we cannot say that the existence of an electromotive force of contact at the junction of two metals is rigorously demonstrated, still less exactly measured, neither can we hold that its existence is disproved.* Experimental evidence in favour either of

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* Appended to Prof. A. Righi's lecture on Volta, delivered at Como, September 18th, 1899.

† Volta divided conductors into two classes, of which the first included all non-electrolytic conductors, such as metals, solid or liquid, and carbon, and the second class included all electrolytes. (Translator.)

‡ This is generally true only when the junctions are all at the same temperatures, but the Peltier effect was unknown to Volta. (Translator.)

* Many physicists hold that its existence has been demonstrated, and its exceedingly small value measured by observations of the Peltier effect (Translator.)

the chemical or of the contact theory, without recurring to Volta's fundamental experiment is greatly wanted.

The hypothesis that the only seat of electromotive force is at a metallic junction would lead to the conclusion that the electromotive force of a cell is independent of the nature of its electrolyte. Now the supporters of the chemical theory have adduced various cases in which an alteration of the liquid may not only affect the magnitude of the electromotive force but even change it sense. To this the supporters of the contact theory promptly replied that these changes of value and sign were due to permanent modifications produced by chemical action on the surfaces of the metals. The so-called passive state of iron was quoted as an example of such a superficial modification.

Though innumerable experiments have been made and described, either in attack on or defence of the theory of contact, an attentive examination shows that none of them are of sufficient weight to decide between it and the chemical theory. In fact, many experiments have lost all value now that we have become better acquainted with the laws of electrolysis.

A mode of explaining this last phenomenon which, as is generally admitted, corresponds perfectly with the observed facts, leaves but little difference between the contact theory, applied to the voltaic cell in the way already explained, and the chemical theory. It is clearly recognised that the current in a cell and the electrolysis which takes place in the liquid are inseparable phenomena, and it is impossible to argue either that the chemical action causes the current, or that the current causes the chemical action. While, however, the supporters of the chemical theory used to assert in a manner that was of necessity vague and ill-defined, that the chemical action is the cause of the current of electricity in the cell, they now limit themselves to stating that the two phenomena are simultaneous, and have for their immediate cause the force of chemical affinity, instead of the electrical force due to the contact charges.

Consider a voltaic cell on closed circuit composed, for example, of zinc and copper and a solution of copper sulphate ($Cu\ SO_4$). While the external circuit of the cell is traversed by an electrical current, electricity is conveyed in the body of the liquid by ions, *i.e.*, to say by electrified atoms or groups of atoms into which the molecules of the salt are split up. In the case considered the ions are Cu and (SO_4), the former of which carry positive charges towards the copper electrode, and the latter carry negative charges towards the zinc electrode, forming ($Zn\ SO_4$). The charges of the ions given up to the metal electrodes feed the current in the external circuit. Within the cell the journeys of the electrified ions constitute a current. On breaking the copper wire which connects the two plates of the cell, the electrolysis ceases with the current and the two ends of the wire are shown to be at different potentials.

From this point of view it may be seen how both the double phenomenon of electrolysis and current in a closed circuit, and the difference of the potentials of the poles on an open circuit are explained by the supporters of either theory. The supporters of the contact theory reason as follows:—On closing the external circuit of the cell the potentials of the copper and zinc plates assume values differing by (c z) the potential difference of contact. The liquid between them now finds itself in a field of electrostatic stress, and the positive ions (Cu) are impelled towards the copper electrode (which through contact with the zinc is negatively charged), while the negative ions (SO_4) are impelled towards the zinc. The + charges which the former yield up to the copper plate, and the − charges, which the latter yield to the zinc plate, tend to charge the two plates; but as these are in contact the difference between their potentials is maintained constant, and the charges received by them produce a current in the wire which joins the poles. If, however, the wire is broken the two metals immediately lose their contact charges, and assume the same potential: electrolysis ceases, and a difference of potential (c z) is manifested at the two ends of the wire.

Those who dispute Volta's principle as applied to metals, and hold to the chemical theory, reason as follows:—Owing to the fact that the affinity between zinc and (SO_4) is greater than that between (SO_4) and copper, immediately on the immersion of the two plates in the liquid the ions (SO_4) begin to travel towards the zinc, yielding to it their negative charges and setting free on the copper plate the other ions (Cu), which yield to it their positive charges. The two plates become thus oppositely electrified, and their charges continue to increase until the electromotive force due to the charges themselves, tending to impress on the ions an inverse motion, arrests the electrolysis. If now the circuit is closed, the impediment to the electrolysis is suppressed, which now continues indefinitely so long as the charges yielded by the ions to the plates maintain the current.*

It is clear now that the whole difference between the two theories is reduced to the following point. According to the first theory, electrolysis is initiated by electrical forces due to contact charges; according to the second theory, electrolysis itself is due to the forces of affinity. It will not be possible to obtain the materials necessary for judgment between the two theories until we have succeeded in measuring satisfactorily the differences at the separate junctions of the bodies forming the couple. This has been attempted in various ways, but the results are neither sufficiently numerous nor sufficiently sure to enable one at present to make a definite decision. It, however, appears probable that the electromotive force of the cell is not identical with the electromotive force of contact between the metals. If this were ascertained, then those who accept Volta's principle should be able to apply it to all kinds of contact, and not only to that between metals. But it does not seem that it would be possible even then to explain with sufficient simplicity all the phenomena of the voltaic cell.

* To this explanation may be objected that no charges are developed on a pair of zinc and copper plates placed in an electrolyte so long as there is no metallic contact between them (Translator).

But even apart from all this, the theory of the pile based on the hypothesis of an electromotive force of contact between metals appears incomplete. It does not, in fact, explain at all the production of current in cells formed of one metal and two electrolytes. Moreover, it is based on a mysterious property of conductors of the first class, which requires explanation in its turn. The chemical theory on its side has its own imperfections. Since it also is based on a special effect produced by the mysterious force of affinity, which equally requires explanation. While, moreover, the chemical theory denies the electromotive force of contact between metals, it does not offer a simple explanation of that between two electrolytes, or between an electrolyte and a metal; and this last must evidently necessarily exist, if that between two metals does not. Taking account of these considerations, the recent osmotic theory of the pile, proposed by Prof. Nernst, seems to present a certain superiority over the others, since, while able to give an account of the production of current in a cell, it neither has recourse to an electromotive force of contact between metals, nor invokes a direct action of affinity, and succeeds, moreover, in explaining easily how the difference of potential is formed between two electrolytes, or between an electrolyte and a metal.

According to the osmotic theory of the voltaic cell, it is supposed that when a molecule is split into two parts, these possess equal electrical charges, positive on one, negative on the other, and of a magnitude proportional to the valency. But instead of supposing, with Grotthus, that this separation of a molecule into ions occurs only during the passage of a current of electricity, or, with Clausius, that it occurs spontaneously and continually in consequence of an incessant interchange of ions between the various molecules, the new theory supposes that free ions of both kinds always exist in an electrolyte, and in greater quantity, according as the solution is more dilute.

To this hypothesis is added another. It is supposed that when a metal is immersed in an electrolyte, ions are detached from it, which remain in the liquid. It only remains to take into account the different velocities with which the ions are diffused to explain how the differences of potential are formed between conductors in contact, and how a cell can generate a current of electricity.

I think it may be useful to close this note with a brief exposition of this ingenious theory.

Imagine, first, a solution which is not electrically conductive to any appreciable extent, a solution, for instance, of sugar in water, separated from a body of water by a semi-permeable membrane, *i.e.*, to say permeable by water but not by the body in solution. Osmosis will occur, and a certain quantity of water will pass by degrees through the membrane into the sugar solution, and so raise its level to such a point that its pressure on the membrane will exceed that produced by the pure water by a certain quantity which is called the osmotic pressure. This phenomenon is explained in the following manner. The molecules of the sugar tend to diffuse themselves in every direction and press on the membrane, which thus become extended, and this causes the pure water to enter the solution. This mode of accounting for the fact ought, I think, to be considered simply as a means of remembering the phenomenon, not as a real explanation. Suppose, now, that the solution is very dilute. Then the more dilute the solution, the more exactly do the following laws hold good.

First of all, the measurements of Van t'Hoff and of Pfeffer show that the osmotic pressure is proportional to the concentration, *i.e.*, to say to the number of the molecules of the dissolved body existing in a unit of volume of the solution. In the second place, the osmotic pressure is the same for all equimolecular solutions (solutions containing, in the same volume, quantities of the solutes proportional to their respective molecular weights) of different substances, and depends on the number, not on the nature, of the molecules dissolved. In the third place, it is proportional to the absolute temperature of the solution. Lastly, from measurements made by Van t'Hoff, the said osmotic pressure is equal to the pressure which the molecules of a gas, equal in number to those of the solute, exert on the walls of a containing vessel, where the volume and the temperature of the gas and the solution are the same. It follows that the body in solution behaves exactly like a perfect gas and obeys the same laws.

The phenomena of osmosis are ultimately connected with others presented by dilute solutions. The vapour pressure of a solution is known to be, at the same temperature, less than that of its solvent. We shall use the term "relative diminution" for the difference between the two pressures, divided by the vapour pressure of the solvent. The boiling point of a solution is known to be higher than that of the solvent, and the freezing to be lower. On the basis of the relations deduced from the principles of thermo-dynamics and verified by experiment, it is found that equimolecular dilute solutions made in a given solvent have not only equal osmotic pressures, but equal relative diminutions of vapour pressures, equal increases of boiling points, and equal lowering of freezing points. It follows that any one of these phenomena can serve for the determination of the molecular weights of dissolved substances. Moreover, in virtue of the thermo-dynamic relations which connect these phenomena, there are several ways of obtaining the value of the osmotic pressure of a given solution.

These laws of dilute solutions have been verified, in every case where measurements have been made of solutions of organic solids in water or organic liquids; generally, in fact, when the solutions are not electrically conducting. In the study, however, of solutions susceptible of electrolysis, such as aqueous solutions of basic salts, acids, or inorganic salts, the osmotic pressure (as also the relative diminution of vapour pressure, &c.) is greater than is indicated by the molecular weight of the solute. These numerous exceptions to the laws of dilute solutions might have delayed the acceptance of Van t'Hoff's theory, had it not been that an attentive examination of the behaviour of electrolytic solutions has shown an analogy to that of

other solutions, based upon an hypothesis which other considerations help to support.

We will use with Van t'Hoff the letter i for the ratio between the osmotic pressure of a given solution having electrolytic conductivity, and the osmotic pressure which the laws enunciated above would attribute to it. This ratio i is usually called Van t'Hoff's factor. A study of solutions of continually increasing degrees of dilution shows that this factor i, while always greater than unity, continually increases, and tends to a limiting value, which is an integer, as 2, 3, &c. When the solution is sufficiently dilute, it behaves as if it contains a number of molecules of the solute, which is twice, three times, &c., the number really introduced into the solution.

The solute behaves here like those gases—hyponitride, for example—which are dissociated on heating and become completely so above a certain temperature. And it is natural to suppose that with increased dilution of a given solution, the molecules of the solute are dissociated more and more, so that starting from a certain degree of dilution, each one of them gets divided into two, three, &c., distinct particles, which behave like the molecules of a gas.

Since these solutions which behave thus are precisely those which are electrolytes, and since it is recognised that electrolysis is due to the movement of ions, *i.e.*, of electrified atoms or groups of ions, by the union of which a molecule is formed, the hypothesis of Arrhenius is immediately suggested, viz., that the particles into which the solute is divided by dilution are none other than the ions themselves.

These free ions are supposed, then, to exist in dilutions, and in greater quantity as compared with the number of entire molecules as the degree of dilution is greater. They must be supposed free to move and to diffuse themselves like entire molecules, in order to contribute to the production of osmotic pressure; but ions of different kinds are to be supposed to diffuse themselves with different velocities.

That these ions possess, at least during electrolysis, different velocities, has long been known. Hittorf showed that in the electrolysis of a saline solution the respective speeds with which the positive ions moved towards the negative electrode, and the negative ions towards the positive electrode, were different, and he determined for various bodies the so-called "convection numbers," the ratio between which is equal to that between the speeds with which two kinds of ions travel towards the electrodes.

On the other hand Kohlrausch, some time afterwards, measured the molecular conductivity of electrolytes, *i.e*, to say the specific conductivity divided by the number of gramme-molecules of the solute contained in unit volume, and has found that by increasing the dilution, the molecular conductivity tends towards a finite limit; and, further, that it can then be represented by the sum of two numbers, of which one is characteristic of one of the ions, and the other of the other. From our point of view these two numbers represent the velocity of migration of the ions themselves.

While Hittorf determined the ratios between these velocities, Kohlrausch determined their sum, so that the value of each can be calculated in an arbitrary unit. It will be seen how important a bearing this has had on the new theory of the voltaic cell.

We may indicate by "a" the ratio between the molecular conductivity of a given solution, and the value to which this would approach with indefinitely increased dilution. This ratio "a," called for obvious reasons the "coefficient of dissociation, or of ionisation," must evidently be related to the factor, i, defined above, if the hypothesis is to correspond to facts.

If the current of electricity in a solution is due to the transport of the electrical charges annexed to the ions, the coefficient, a, should be equal to the ratio between the number of dissociated molecules, and the total number of molecules in the solution. Let us call this last number "n." The solution will then contain $n-an$ entire molecules, and an dissociated molecules. If we supposed that each of the latter is divided into "p" parts, the total number of such parts will be "pan." Then the total number of particles existing in the solution (entire molecules and free ions) will be $n-an+pan$. Now, i is the ratio between this number, and n the total number of molecules of the solute. Hence $i = 1 - a(p-1)$. Repeated experiments has confirmed this relation, and thus affords a verification of the hypothesis of electrical dissociation.

We are now in a position to give a general account of the osmotic theory of the cell based upon this hypothesis.

Consider, first, two solutions of the same salt of different degrees of concentration placed in contact. It is easy to demonstrate that in this simple case a difference of potential will immediately be formed between the two liquids. For what will happen will be that ions will diffuse from the concentrated solution into the dilute in greater number than they will diffuse from the dilute into the concentrated; and since the positive ions diffuse themselves with a velocity different from the negative, it will necessarily happen that in one solution positive ions will accumulate, and in the other solution negative ions. The two liquids will then appear to be oppositely electrified, and the difference of their potentials will continually increase until the electrical forces, which clearly tend to oppose the osmotic action, are sufficient to arrest it. Evidently, to maintain a steady action, the character of the two liquids must be kept constant.

For other cases of contact between liquids the explanation is not so simple. Nevertheless, it is easily seen that if instead of two solutions of the same salt of different degrees of concentration, there are two different electrolytes, there will arise, in consequence of an osmotic process similar to that which has been described, a difference of potential between them due to the difference of the velocities with which the ions are diffused from either one into the other. This difference of potential will depend on the nature of the two solutions, and on their concentrations; and obviously cases will occur in which no difference of potential arises.

Suppose now that two electrodes, formed from the same metal, are immersed in the two liquids and connected with one another so as to form a closed circuit. The charges of the two liquids will then be neutralised, or rather, the electrical forces will be annulled which oppose the continued separation of the positive from the negative ions, and this osmotic separation will now be able to continue indefinitely, and will produce a continuous current in the wire which connects the two electrodes.

But in reality the presence of the metal immersed in the liquids may alter the character of the action profoundly. To explain the effect exercised by the character of the metal on the electromotive force of a cell (of one constituted, for example, of two liquids and one metal) a new supposition is required. Nernst supposes that, in the same way as the ions of a liquid diffuse themselves into another liquid with which it is in contact, so free metallic ions leave the mass of the metal to diffuse themselves in a liquid in which it is immersed. In consequence of this process a difference of potential will be formed between the metal and the liquid. Thus if the metallic ions gave a positive charge, the metal will remain negatively electrified, while the liquid will appear positive, and a difference of potential will be formed between the metal and the liquid.

This emission of ions by a metal may be compared to the evaporation of liquid in a closed vessel, which only ceases when the vapour formed has reached a certain pressure. One may say, then, that metals possess a proper "solution tension," just as liquids possess a "vapour tension," and this solution tension may be measured by the osmotic pressure produced by the metallic ions diffused in the electrolyte. We may by analogy suppose that there is a similar emission of ions from a non-metallic body in contact with an electrolyte. Oxygen, for example, in such circumstances will emit negative ions. This explanation of the difference between the potentials of two liquids, or between a liquid and a metal, explains also the formation of a difference between the potentials of the poles of a voltaic cell, or in the case of a closed circuit, the origin of the electrical current. All depends upon the various velocities with which the ions are diffused from one body into another, and so on their respective osmotic pressures.

The differences of potential can be calculated for particular cases, when the relative osmotic pressures are known of the various ions. Thus in the case of the difference between the potentials of two liquids one calculates first the work done in conveying the ions from one liquid, in which the relative osmotic pressure has a certain value, into another liquid, where the said pressure has a different value; in the same way as one would treat the passage of a body of gas from one pressure to another. This work may then be equated to the product of the difference of potential by the quantity of electricity which the ions have transported. The procedure is similar for the difference between the potentials of a metal and a liquid, only here the osmotic pressure in the metal is replaced by its solution tension.

In the few cases in which the electromotive force of a cell has been both calculated, and experimentally measured, a satisfactory concordance has been found. This has been carefully done for cells of the Daniell type. In the calculation the differences of potential between the two metals and between the two liquids have been neglected, being considered *a priori* as being very small. It seems then that the predominating electromotive force has its seat at the contact between metal and liquid; those which occur between metal and metal, or between liquid and liquid, are very small indeed.

It is impossible to say that the osmotic theory of the pile excludes the possibility of a contact force between metals, and if the latest comparisons between the results of calculation and experiment have proved its existence, an explanation of it may, perhaps, be sought in the difference between the solution tensions of the various metals, by reflecting that the existence of electrolysis has now been ascertained in some solid bodies, such as, for example, in glass at a temperature little above normal.

If the osmotic theory of the pile furnishes an explanation of the electromotive force of contact between two metals, or in general between two solid bodies, one might go farther and attribute to reciprocal contact the production of electricity by stroking bodies, by cleavage, by the separation of bodies already in contact (as, for example, in the act of contraction by one of them through solidification), &c. In the case of insulators, the effect of rubbing and close contact is only to multiply the points of contact, and to reduce the distances between the parts of the two bodies which are affected before separating them.

The osmotic theory of the pile is thus seen to account in a simple way, not only for the complex phenomena presented by the voltaic cell, but for the differences between the potentials of bodies in contact (or, at least, all except those between metals), and seems now to deserve the attention of physicists.

AMERICAN v. BRITISH WORKMEN.

An occasional correspondent of the *Engineer* endeavours to arrive at some explanatory causes of the much debated question of American competition. The true basis for difference he holds to be summed up in the three words, food, climate, and society. Manufacturing America lies approximately between latitudes 32° and 42°, but is bounded west of the Mississippi at present. An extreme dryness and an enormous range of temperature are the main features. South of the Ohio the extreme cold is wanting, but the summer heat is so excessive as to lead to the large employment of coloured men. The climate he looks upon as causing a craving for a meat diet, and meat is consumed in plenty, and half raw. The same meat diet, though less raw, is

characteristic, curiously enough, of those who dwell in the hot climate of Australia. This diet enables a man to work hard from 21 to 45 years of age, when he becomes played out. We presume the writer is speaking of manual workers. We do not think his last statement is so applicable to professional men and business men. But what becomes of the American workmen, when at 45 they stand aside "nervous and dyspeptic?" They ought by this time to have grown into a large leisured class, or to be an army of paupers dependent on friends. We think the picture overdrawn to some extent. We do not recognise the relentless energy of which so much is talked. Americans work hard and for long hours, and have no holidays, but much of this is due to their own choice, and is not doing the people any good as a mass any more than the similar conditions improved the physique of the English people in the pre-Factory Act days.

The author does pretty correctly determine one reason for great productiveness in American works. There are no boys—no apprentices—in many of them. Their business is to make money. It is no part of the social scheme of an American employer to provide workmen for 10 or 20 years hence, when his own descendants have perhaps gone West as tramps, or gone East to Europe as multi-millionaires to re-build the fallen fortunes of titled people. The American employer has had so much skilled labour from Europe to do his work that he has had no occasion to worry about training apprentices. The best skilled workmen in America are English. The attendants on machine tools are probably largely American. The unskilled labourers are of Italian or middle European origin—ignorant, and thus easily run by gangers of their own race who happen to have acquired English. There are also the Irish, who seem to run the whole of political America. They are almost uniformly at enmity with England for some reason, or lack of reason, except in rare instances where they realise facts on a true basis, and they are responsible, together with the primary school history of America, for fostering the spirit of Anglophobia, which recently in Massachusetts passed resolutions in favour of the Boers for doing that which, as attempted 125 years ago by England very mildly, has been the cause for the last century of teaching American children that all Englishmen are bloodthirsty tyrants.

The finest class of workmen in America, so far as our limited observation goes, are the locomotive drivers. They have much the same style as the old-time English millwrights. Generally, however, says the author, the native American aims at a boss position, and those who fail to attain it swell the army of telegraph clerks and tramcar conductors. The struggle for respectability—meaning a black coat and clean hands—appears as keen as in Europe.

Labour troubles in America do not exist as we know them, because it is difficult to get a heterogeneous mass of different nationalities into line and discipline; but when there are troubles, they are usually associated with the wildest orgies, riots, and incendiarism, unknown in England, but probably of Continental origin, where, as we recently have learned from the German press, English ideas of freedom are hated, and our race detested, with the same virulence as is exhibited by these same foreign ruffians when they fail to secure their ends reasonably in America.

The author further argues that just as sheep and cattle in Ohio, Australia, or the Argentine may yield better than the original British sheep, yet this yield is only kept up by constant replenishment from England; so in America the race is not self-continuing, the birth rate is going down, if the real native element could be statistically differentiated, and the country is populated and replenished from abroad. It was argued very powerfully by Trollope that the future of the West Indies was all wrapped up in the brown man, and if it should be proved that even south of latitude 42° the same effects of climate are, though to a less extent, holding sway, the future may see a solution of the negro question, to contemplate which would be most distasteful to present-day Americans, who are not even civil to anyone who can even be called sunburned. But these speculations are, like those of the author, premature. The population of America is still so heterogeneous, that the one-time type of American—long and lank—has very much disappeared, and there has indeed not been sufficient time to evolve a permanent type. Americans of to-day far more resemble the bull-necked and well-fed individual caricatured by them as John Bull, than do Englishmen. As regards social equality, and all that sort of thing, our correspondent adopts the conventional American style, which remains as a legacy at most from the old Colonial days, and has no real basis. Jack is as good as his master, no doubt, in America, as he is in England, except that he goes one better in England.

Now as to the American system of manufacture, the standard products, and the so-called English manufacturer's refusal to alter his designs. It appears that no manufacturers are so stupid, if it be stupidity, as the Americans; they reply, buy what I make or leave it. This—in an American a gross fault—in an English manufacturer is a virtue. Of course, the question comes in as to design, but on this score we must not forget that where we have been at fault has not been in our manufacturers' designs, but in the designs of Westminster engineers of no practical knowledge or experience.

A certain firm of Westminster engineers, says our contemporary *Engineering*, prepared designs for a bridge two or three years ago. To this design the Patent Shaft and Axletree Company have built the new bridges for the Tugela and Frere rivers in Natal, the spans weighing 105 tons in place of 45 tons, which the Natal Government engineer says would have been equally strong. The heavy design was adopted to save time, as it was expected, of course, by this time, that the "simple-minded farmers and their French and German colleagues" who destroyed the previous bridges would have been persuaded to leave the neighbourhood of the Tugela.

We wonder what the well-known firm of consulting engineers in Westminster thinks of our contemporary's savage onslaught on its design—an onslaught none too savage to hurl at a good deal of Westminster designing, which has been responsible for much unnecessarily costly work.

Finally, if there is one thing more than another that shows the weakness of workmen as a class in America, it is the abominable truck system, which flourishes to so grave an extent that company prospectuses are put forward in which the company store is exploited as a means of getting back a rebate on the wages paid. This evil was abolished over 50 years ago in Great Britain. It formed, we believe, a convenient means of disposing of cargoes of damaged flour and other rotten and poor produce, and it is not likely to lead to better things in America. It appears to attain its maximum of evil in the State of Pennsylvania.

The conclusion drawn by the author is that American competition is not to be feared on account of the workmen, but that the natural resources of the country are more likely to be a prevailing influence. Food is said to be cheaper than elsewhere. This we do not think is the case. In the matter of food, London is cheaper than, say, New York, and probably the ratio applies to other parts.

If what the author says as to men being worn out at 45 be even approximately true, the time cannot be far distant when Americans will find it necessary to live more rational lives, and we shall see a falling into line with methods of life and a certain waste of time in holidays which have been evolved by a longer experience on this side, and by passing through a period when the degeneracy of the population of the cities became sufficiently apparent for its cause to be appreciated, and, on the whole, grappled with.

It seems to us that Americans are working themselves to death—very much as they have exhausted some of their once fertile lands which are now in desolation. These are all the well recognised faults of new countries. They will probably cure themselves before they harm the rest of the world, but our future food supplies will be straitened if no other source than America opens up. The cost of living in America has been greatly enhanced by their protective policy, and it is necessary for the whole nation to work longer hours in order to earn the difference. The higher rate of wages in America in rare cases implies a really better income as regards comfort in living. In many cases it means far less comfort if the necessities of climate are considered, while in many cases wages are actually lower in amount. There are, if we are to judge by a recent article in an American journal, no such poverty-stricken areas in this country as are to be seen in Pennsylvania. It would appear that apart from magnificent organisation, much of America's progressing competition arises from a prodigality of life and of the soil's fertility which cannot endure, and as Americans awake to the dangers of the uneducated Huns of Middle Europe who constitute so much of the rowdy element, they will see the folly of killing in order to keep themselves, and fall more into line with a mode of life that has been evolved by experience and proved to be enduring.

We need not follow the author in his remarks on the superiority of American workshops, and so on. There are some shockingly filthy shops in America, as here, but, on the whole, American workshops are newer than our own, and as a rule things of to-day possess features not known even 10 years ago. These are mere details of difference rapidly disappearing with the older shops. Even as we write, we find American competition to be less keen. Representatives on this side are putting up prices as business improves in America, and are checking sales, and our own manufacturers are getting over the period of retrogression which was brought on by the methods against which the employers revolted in 1897—methods, the nature of which was never so clearly manifested, we trust, to English workmen as it is, perhaps, to-day, when they see their supposed German friends of 1897 now subscribing to destroy English trade in South Africa by getting us turned out thereof.

THE CORLISS ENGINE.

A RECENT issue of the *Engineer* of New York was devoted almost wholly to a history and description of the Corliss engine. It is there stated that the first drop cut-off mechanism was invented by Sickles, in 1841, while the Corliss engine, which has been said not to have been really the invention of Corliss, was patented in 1849. We are not in possession of a minute history of drop-valve gear, but think it possible that valves, the movements of which were free from their driving gear, were in existence earlier than 1841. One gear especially, consisting of a vertical spindle rotating with discs carrying lift cams, clearly comes under the description, and we believe is of considerable age, but the slowness of adoption of the Corliss valve in this country was certainly not that cut-off was unappreciated, for the devices tried were numerous, and are, like the Corliss, in existence to-day. Thus the old D slide was fitted with internal flat cut-off plates, and an exceedingly rapid cut-off motion, little inferior to that of the Corliss gear, even in the light of present day knowledge. The Corliss was, we believe, brought over to this country by the late Mr. Inglis, a Canadian engineer, and late of the firm of Hick, Hargreaves, of Bolton, in conjunction with Mr. Davidson, who was a son of the manager of the Bank of Scotland, in Edinburgh, and afterwards went to New Zealand where he ran a foundry and built indiscriminately, or indifferently, as the Elizabethans would style it, stern wheelers, small locomotives, pit-head work, *et hoc genus omne*, filled the various demands of a new colony, while he spent leisure hours as starter in the local races. Peace be to his ashes.

Corliss, like everyone else probably at the time, no doubt fully believed that the good results he obtained were due to his excellent mechanism. He may be excused in this, seeing

that to-day each new firm that essays to build engines acts on the assumption that economy of fuel is to be obtained by a sufficiently cumbersome agglomeration of links and pins, which is really a better name than valve gearing for some of the modern abominations. The real cause of the economy he secured was, probably, the better drainage of the cylinder, combined with better workmanship.

There were four valves placed at the opposite corners of the cylinder rectangle, the steam valves discharging directly across to the exhaust valve chamber or port, and water passing out of the cylinder at once when the exhaust valves opened. All the four valves were operated by one eccentric, which gave an oscillating movement to a wrist plate, from which the four valves were driven by short connecting rods from four pins set in the face of the plate.

The steam valves, alone, had a disengaging or trip motion somewhere in this connecting mechanism, and this trip motion was worked by means of a little trip cam set at a varying angle by the governor. Thus the governor had no work to do, and could be small and light. Corliss also effected improvements in the framing of his engine.

There are numerous makers of Corliss engines to-day in America, and they use various modifications of the trip gear in the same way as so many modifications have been used on this side. A usual method there is to hang a bell crank or gab jaw by a pin upon the valve spindle lever. The inside face of the gab carries the hardened steel catch or trip piece, while the other fork of the gab acts as the trigger and trips the valve as it turns by coming into contact with a cam, the position of which is varied by the governor. The great drawback to the Corliss engine has been the difficulty of using a cut-off other than early. Thus overloads have been impossible, but long range cut-offs are now made, and the engine can carry a considerable overload for, it is said, short periods, but why not for long periods does not appear. The great objection to-day to the Corliss gear is, that engine speeds have gone beyond the speeds at which trip gears can be successfully worked, and American high speed engine builders have dropped the Corliss gear, and employ direct driven valves. It is probably due to the limiting influence of the Corliss valve that American engine builders, in cases where the Corliss valve is still made, are so determined to force heavy and slow rotating engines upon traction stations. It is open to question whether, in sticking to a good valve and gear, simply because they are good, the limitations of the gear have not been glossed over. Extreme sharpness of cut-off is now known not to be of such terrible consequence, while other valves give rapid opening, even if not so smart at the cut-off.

In the article before us descriptions, many of them illustrated, are given of the engines made by a large number of firms. So numerous are these makers of Corliss engines and so invariable the system of naming their engines Smith-Corliss, Brown-Corliss, &c., that they have been dubbed with the generic term of hyphen Corliss engines. Full particulars are given of the peculiarities of valve setting and very extensive tables of principal dimensions for various steam pressures, powers and cut-offs, mean effective and terminal pressures, theoretical and actual steam consumption in condensing and non-condensing engines, which will be useful to designers and engineers generally. Probably no engine has had such a run as the Corliss, and its hold is still very strong even in vertical work where the drainage facilities that have done so much for the engine, are half lost.

ELECTRIC LIGHTING LOANS.

The Inquisitorial Attitude of the London County Council towards the Vestries and District Boards.

It is clearly obvious that the attitude recently assumed by the London County Council in regard to the sanctioning of the borrowing of money by Metropolitan Vestries and District Boards for electric lighting purposes is reaching such a critical stage as to necessitate an important reform in the offices at Spring Gardens. The position of the County Council in this respect is clearly of the Paul Pry order, which, if no changes are made in the present policy, is likely to arouse a spirit of opposition throughout London, in so far as those local authorities are concerned which have embarked in electric lighting undertakings, and which, in their desire to meet the increasing demand for light on the part of the public, seek to raise the money by way of loan, a course which first requires the sanction of the London County Council. For the moment it is not so much the new undertakings which are affected by the inquisitorial part played by the County Council—it is rather in the case of the older systems that the leading spirits experience the delights of being brought to book by the creatures posing as omniscient beings at Spring Gardens.

It may be that the London County Council thinks that it is right to satisfy itself as to the legality and reasonableness of proposed expenditure before giving sanction to local authorities, but as the Council knows thoroughly that at least some of the vestries and boards of works are undertakers under the Electric Lighting Acts, that finally disposes of the question of legality. But when we consider the point of reasonableness there is reason to believe that the Council is exceeding not only the practice of the late Metropolitan Board of Works—a practice which the Council itself cites against one local authority as a reason for insisting upon details of expenditure—but that it is also going beyond the policy of the Local Government Board when dealing with applications from local authorities throughout the country for sanction to the raising of loans. It is the demands put forth on behalf of the Council for minute particulars of projected outlays that are so annoying and vexatious to electric lighting committees and their engineers in various metropolitan districts, and, as will subsequently be seen, the County Council is making itself ridiculous by placing upon the Electric Lighting Acts, an interpretation that, we feel sure, was never contemplated in relation to the duties of the sanctioning authority in London when those measures were passed by Parliament.

As an illustration of some of the information required by the County Council at the preliminary stage of applications for borrowing powers, attention may be directed to Form E issued by the Council, a copy of which has fortunately been placed at our disposal, and which we do not think has previously been published. The form is headed "Particulars required for proposed loan of ——— for electric lighting undertakings, dust destructor machinery or similar works," and in the case of the erection of buildings a separate form is supplied by the Council. What the County Council asks for in this respect may, with interest, be reproduced as follows:—

Particulars Required by the Council.

Note.—If the application be for a further loan for or in connection with work for which a loan has already been sanctioned, it should be stated on this form whether any, and if so what, particulars given for the earlier loan are applicable to this one.

(*a*) Send general plan of buildings, showing the arrangement of plant and machinery.

(*b*) Send copies of contractors' drawings, specifications and estimates, and priced bills of quantities of plant and machinery. (If any work is done directly by the local authority equivalent information should be supplied.)

(*c*) In the case of applications for a loan for mains, supply a plan to the scale of at least 5 feet to the mile, showing the positions of the mains, kind of paving beneath which they are laid, street boxes, service boxes, street, arc or other lamps, &c., together with full particulars of the mode of laying cables—whether in culvert, pipe or otherwise—sectional areas of the various lengths of mains, description of them and the method of insulation, and detailed drawings of street boxes, culverts, and sub-stations (if any).

(*d*) State cost of the following articles separately, with a full statement of what is included under each item:—

(*e*) State engineer's charges.

(*f*) State salary of clerk of works for plant and machinery, &c.

We have omitted the numerous "articles" specified as following under (*d*) but they will be understood to refer to all the machinery and plant inside and outside the generating stations. We should, however, state in this connection that the particulars required of street arc lamps, street lamp-posts, sub-stations, mains, street, &c., boxes, culverts or pipes, trenching and re-instating streets, should, in the opinion of the Council, "agree with the numbers and lengths shown on the plans, or the reason for any difference explained." As to connections to consumers, details and number of consumers are to be stated. All the items have to be priced out and detailed, from the type of meter proposed on the one hand, to the number, description, and heating surface of each boiler, and the number, description, speed and output of each dynamo and engine on the other. It is clear, from the requirements here pointed out, that the London County Council affects to ignore the experience of the electrical engineers employed by the local authorities, and has instituted a system of checking the expenditure proposed by these authorities—a system that is obviously being sought to be enforced by those who neither seem to possess the necessary experience or knowledge, nor are likely to acquire those qualifications so long as they sit on office stools at Spring Gardens.

Let us take one concrete instance. Some months ago the Islington Vestry applied to the Council for sanction to borrow £13,200 for additional plant at the Eden Grove station. In November the Council decided not to grant permission until further particulars were supplied, and on January 30th a loan of £10,000 on account of the £13,200 was sanctioned. As to the difference of £3,200, the Finance Committee stated that they had "informed the Vestry that if they will supply such details and information as would justify the borrowing of the balance, we shall be prepared to consider as to sanctioning the borrowing." The absurdity of this statement is remarkable when it is borne in mind that every possible detail has been furnished by the Vestry—the more so when the separate items comprised in the proposed loan not only include the Vestry's estimate, but also the actual quotations of the makers for the supply of the plant. As this particular case is of unusual interest, we set out below the details of the items in question:—

	Vestry's estimate.	Maker's quotation.
Steam and other piping and valves	£4,950	£4 950
Combined heating, softening, and filtering plant	1,150	1 154
Electric coal-tipping winch	400	400
Six superheaters on new boilers	1,200	1,200
Four superheaters on old boilers	700	560
Auxiliary apparatus—three pumps	800	780
Condensing plant	4,000	4,290
Total	£13,200	£13,334

With regard to the difference in estimate and quotation for the four superheaters, as the latter have to be affixed to old boilers, there will necessarily be some alterations required, and £140 has been added for this purpose. As to the three pumps, the price is £260 each, with £20 added for contingencies.

Leaving the above figures to tell their own tale, it remains to be seen what the Islington Vestry will now do in regard to the matter, although, as will be seen, the whole question has been referred to the Electric Lighting Committee for consideration and report. In the meantime it should be stated that similar difficulties have arisen in other districts. The St. Pancras Vestry to some extent eventually solved the problem by first borrowing and spending the money and then seeking sanction. This has led to large overdrafts from the bankers, the sum on one occasion last year having exceeded £40,000. The account of the Shoreditch Vestry a few weeks ago was overdrawn to the extent of £25,000 owing to a similar difficulty of obtaining sanction to loans or advances of loans on the part of the London County Council, and we believe that other districts are beginning to experience the arbitrary and domineering attitude of the County Council in this respect.

There can be no question that some radical alterations in the policy pursued at Spring Gardens are imperatively necessary if further

friction between the Council and the local authorities in general is to be avoided, and electric lighting is to be developed and not hampered by unnecessary restrictions sought to be imposed by the County Council. Next year it will be possible for the Borough Councils, as the Vestries will then become, to appeal to the Local Government Board in case of refusals to sanction on the part of the County Council, but as such appeals can only be prosecuted after a period of six months their value can only be regarded as infinitesimal, if, indeed, the appeals will prove of any benefit whatever in view of the low speed advocates who superintend local government matters in Whitehall. It is bad enough for provincial authorities to wait for months in regard to Local Government Board inquiries and decisions; what will be the position when the Board becomes the court of appeal for the new borough councils against the London County Council? The outlook is not promising, and the only real remedy in case Spring Gardens will not listen to reason, will be for the metropolitan authorities to combine in order, if possible, to secure an alteration by appeal to the Board of Trade, or to obtain the transfer of the powers of sanctioning loans to another body or department.

The Position at Islington.

The Islington Vestry, at the meeting on Friday, considered the subject of sufficient importance to discuss certain correspondence read from the London Council in reference to the Vestry's application for sanction to borrow money for electric lighting purposes. In brief, the Council intimated its willingness to sanction £10,000 out of £13,200 applied for on account of new plant, and of £38 000 out of £56,261 required for extending the system to Highbury Hill.

Mr. Gordon, chairman of the Electric Lighting Committee, moved that the Vestry should decline to accept the sanction for £10,000 and £38,000 on account. The County Council were taking up the position that the prices were estimates, whereas they were those of the makers, and the speaker then quoted the figures given above. It appeared to him that the Council thought the figures were prepared by a non-practical man, but it seemed that the Council had them revised by those who did not understand the business.

Mr. Dryden, in seconding the motion, said that the work was their work, and they ought to be allowed to carry it out to their own satisfaction. He believed they were as capable as the London County Council in getting value for money.

Mr. W. F. Dewey, vestry clerk, then quoted from a letter received the previous day from the County Council in reference to further particulars required in respect of the balance of the loan of £56,261. In one case the Council stated that the excess of cable required on comparing specified lengths with those measured on the plans was 38 per cent. and in another instance 58 per cent., whereas 25 per cent. was said to be excessive. That was one of the points upon which the Council desired information.

Mr. Elliott, L.C.C., said that if 25 per cent. of waste was sufficient, why was 58 per cent. asked for? Under the circumstances, further information should be given.

Mr. Tomkins desired to know what the Electric Lighting Committee would do if they refused the County Council money—the only source from which they could obtain sanction to borrow.

Mr. Mills, as an amendment, proposed that the Finance Committee of the London County Council be asked to receive a deputation from the Finance and Electricity Committees for the purpose of arriving at a speedy settlement of the outstanding questions. The County Council had said that it would receive the Committee at any time, and if a deputation attended they would better be able to understand the views of the Council than at the present time. It seemed to him that it was nothing more or less than a committee standing on its dignity to the extent of desiring the Council to send the invitation for a deputation, but he thought the Vestry should take the initiative in the matter.

Mr. Eggett, in seconding the amendment, observed that constant friction occurred between the Electric Lighting Committee and the County Council, but if they met round a table to discuss the question, good results would ensue.

Mr. A. Gay, the Vestry's electrical engineer, stated that the letter from the Council had been brought to his notice the previous day. He had commenced to investigate the matter, but had not been able to complete it, although the whole question would be before the Finance Committee next week. With regard to the statement of 38 per cent. excess, that was 9 miles to 12½ miles, that was incorrect. The excess of cable beyond that of the frontage was only a bare 20 per cent., but it was evident that whoever made the statement that it was a 38 per cent. increase, had not understood the extensions and the plans, and he might say that that was not the first time ignorance had been shown in the reading of plans. It was not to be assumed that he would put down 58 per cent. more cable than was needed. If he wanted 10 miles of cable he ordered it, but in this particular case nothing had been ordered. In the first instance the London County Council was absolutely wrong, and he could only assume that the Council had made a gross error in the reading of the specification or plans. He had not gone into the other items, but he felt perfectly confident that his explanations would be satisfactory to the Vestry. A waste of 20 per cent. was excessive, but it was accounted, among other causes, by the loose cable lying in the boxes for connections, by bends, twists, and turns, including those round pipes, and by other things which ran away with a certain amount of cable. In addition, there were the actual connections to the transformers, and if they would allow him, he intended to place the whole matter before the Finance Committee.

After further discussion, the whole of which extended over a considerable time, the amendment was adopted by 35 votes to 16 votes, and on being put as a substantive motion a further amendment was proposed and carried adjourning the consideration of the question, and referring the letters from the County Council to the Electric Lighting Committee for consideration and report.

PHYSICAL SOCIETY.

Ordinary Meeting held January 26th, 1900.

Prof. Lodge, F.R.S., President, in the Chair.

A paper by Prof. Ayrton and Mr. Mather on "Some Developments in the Use of Price's Guard Wire in Insulation Tests," was read by Prof. Ayrton

For insulation tests made by the direct deflection method the guard wire properly applied affords complete protection against surface leakage when the ends of the cable tested are near the galvanometer, so that it is possible to have the wire connecting the conductor of the cable with the galvanometer terminal "air insulated." A difficulty, however, arises when the ends of the cable are at a considerable distance from the testing instrument; this may render air insulation impossible. The authors have overcome this difficulty by applying a guard wire along the entire length of the lead. This is done by using a concentric wire to connect the cable and galvanometer, the inner of the concentric being used as the lead and the outer as the guard wire. The principle can also be applied to determine whether a defective piece of cable is bad throughout, or bad owing to one or more isolated faults. In this case the cable is placed in two water tanks, one of which is earthed and the other fairly well insulated. By a suitable arrangement of the guard wire it is then easy to determine the resistance of the wire in the earthed tank, so that by altering the length of this wire the character of the insulation can be determined throughout the whole length of the cable. In referring to some of the earliest experiments with the guard wire made by Mr. Appleyard in 1895, Prof. Ayrton pointed out that the principle had not been applied completely and that at one point there was a chance of leakage.

Mr. Campbell said that the necessity of having a concentric wire could be obviated by simply hanging the lead from the guard wire by short lengths of material of fair insulation.

Mr. Appleyard said that he quite agreed with Prof. Ayrton that the guard wire ought in general to be applied at both ends of all leads, provided that both ends could be got at. The reason it was used at one end only in the experiments on dielectrics made in 1895 was that the far end of the lead was carried into the condenser box which was submerged in water in the temperature tank, special precautions were taken to ensure good insulation of the submerged end of the lead, and tests showed that the leakage there was *nil*. As the end of the wire could not be got at, no guard wire could be applied. Mr. Appleyard congratulated the authors upon the use of a concentric cable for a lead, and pointed out that such a lead was sufficient for all the routine tests on core; the inner and outer conductors could be used for the purpose of taking the "copper" resistance. Mr. Price expressed his interest in the developments of his principle which had been made by the authors.

Mr. Appleyard then read a paper on "A Fault-Test for Braided and Other Cable Core."

This method enables the fault to be found without the removal of braiding or tape. The core is wound on two insulated drums or tanks, the intermediate piece of cable being about 10 feet long. One end of the core is left free, the other is connected to earth through a galvanometer and a battery. A guard wire is connected from some point between the galvanometer and the battery to some point of the braiding on the wire between the drums. A wet cloth, connected to an earth wire, is laid on one or other of the drums, over the braiding. The galvanometer deflection is noted. The earth wire is then changed over to the second drum and the corresponding deflection is observed. A comparison of these deflections at once indicates upon which drum the fault lies. With the galvanometer still deflected the core may be run through a suitable contact brush or sponge attached to the guard wire. The instant the fault passes under the guard wire contact, the deflection falls and the fault is located. The paper gives the theory of the method and indicates how to apply it (1) to localising "distributed" faults; (2) to several faults in a single cable, and (3) to the case of a single fault. One advantage of the method is that at the critical moment when the fault passes under the guard wire the galvanometer is short-circuited through the fault and thus completely protected.

A paper on "Reflection and Transmission of Electric Waves along Wires," by Dr. E Barton and Mr. L. Lownds, was read by Dr. Barton.

The waves used were produced by means of an induction coil and an oscillator and travelled along wires ·15 cms. diameter, 6 cms. apart and 166 metres long. The ends of the wires were connected by graphite markings on ground glass, so that any wave trains which reached the ends were at once absorbed. Three circular parallel-plate condensers were used of 15, 9, and 5 cms. radius respectively. The plates were in all cases separated by air and were placed 1 cm. apart. The needle of the electrometer connecting the wires was uncharged, so that it was always attracted by the charged plates. The positions of the condenser and electrometer could be varied so as to study either the reflected or the transmitted waves. The electrometer produced a negligible disturbance as it reflected only 0·04 per cent. of the energy incident upon it. The authors have attacked the problem, mathematically using the relations of Heaviside, and have obtained expressions for the reflected and transmitted systems. These expressions consist of two terms, one of which is comparatively unimportant. From the other term certain values have been calculated. A superior limit was then given to the other

term, and the values already obtained have been subjected to a correction on this account. By a suitable arrangement of the condenser and electrometer these calculated values have been experimentally determined, and are in close agreement with the theoretical numbers, falling in many cases between the results derived from the approximate and the corrected theories. The authors have also investigated the stationary wave system produced by interference when the electrometer is placed close to the condenser, and between the condenser and the oscillator.

The CHAIRMAN said that the experiments afforded a satisfactory verification of Heaviside's theory.

A PAPER ON "THE FREQUENCY OF TRANSVERSE VIBRATIONS OF A STRETCHED INDIA-RUBBER CORD," by Mr. T. J. BAKER was taken as read.

In this paper Mr. Baker has investigated the frequency of the note given out by an India-rubber cord of square section when subjected to different tensions. The relation between length and tension is linear over a considerable range. The curve connecting length with frequency shows that while the cord was doubling its length the pitch was rising rapidly, but that further extension was practically without effect. Since the relation between length and tension is linear, while the sectional area is decreasing, it follows that the value of Young's modulus must be changing. The author has shown that the value of Young's modulus is proportional to the square of the stretched length of the cord. Using this fact the frequency of the note given out by a stretched India-rubber cord is shown to be proportional to a quantity which varies very slightly with increase in length of the cord, and hence the variation in elasticity is given as the cause of the constancy of the note.

Mr. APPLEYARD exhibited some mirrors produced inside incandescent electric lamps by the application of voltages much above those for which the lamps were designed and the consequent deflagration of the filaments. The meeting then adjourned until February 9th.

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS

NEW PATENTS.—1900.

led expressly for this journal by W. P. THOMPSON & Co., Electrical Patent Agents, 322, High Holborn, London, W.C., and at Liverpool, Manchester, and Birmingham, to whom all inquiries should be addressed.

1,407. "Improvements relating to electric traction." R. BROWN. Dated January 23rd.

1,445. "Improvements in electric transformers." A. H. LORING and H. L. CLARK. Dated January 23rd. (Date applied for under Patents, &c., Act, 1883, Sec. 103, June 24th, 1899, being date of application in United States.) (Complete.)

1,449. "Improvements in or relating to electric glow lamps." D. R. BROADBENT. Dated January 23rd.

1,450. "Push for electric bells or the like." T. HOLME. (J. V. J. Silfverberg, Denmark.) Dated January 23rd.

1,457. "Improvements in and relating to electrolytic apparatus." W. BARNES. Dated January 23rd. (Complete.)

1,464. "Improvements in surface contact electric railway systems." J. M. MURPHY. Dated January 23rd. (Complete.)

1,475. "Improvements in electric igniters for explosion motors." J. SCHIELE and J. B. BOISSELOT. Dated January 23rd. (Complete.)

1,512. "Improved method of holding magnet winding." W. G. PRIMROSE. Dated January 24th.

1,528. "Improvements in continuous current dynamos and electromotors." J. SCHUIL. Dated January 24th.

1,531. "Electric light dimmer." J. R. HATMAKER. Dated January 24th.

1,537. "Improvements relating to the preparation and treatment of filaments for incandescent electric lamps." C. GARNER. Dated January 24th.

1,555. "Improvements in the method of transmitting electric energy through ether and devices for same." E. G. FORESIO. Dated January 24th.

1,566. "Improvements in or relating to accumulator plates." M. WUILLOT. Dated January 24th.

1,568. "Improvements in or relating to electrolytic electricity meters." C. O. BASTIAN. Dated January 24th.

1,573. "Improvements in or relating to rubber insulated electric cables." G. E. HEYL-DIA. Dated January 25th.

1,578. "Improvements in and in connection with trolley poles of electric tramcars." W. GLOINSON. Dated January 25th.

1,583. "Improvements in or relating to the manufacture of electric cables." G. E. HEYL-DIA. Dated January 25th.

1,605. "New or improved electrical influence machine for transforming mechanical energy into electrical energy or electrical energy into technical energy." W. E. AYRTON, W. F. CRAWFORD, and H. J. THOMSON. Dated January 25th.

1,617. "Improvements in or connected with carbon contacts for electrical switches and the like." A. REICHWALD. (The firm of Fried. Krupp, Germany.) Dated January 25th.

1,618. "A new or improved method of and device for regulating or controlling electrical switches." W. KINGSLAND. Dated January 25th.

1,653. "Method of boosting a direct current of electricity by means of an alternating current." D. COOK. Dated January 26th.

1,679. "A new and improved method of and process for insulating electrical wires." H. W. WEBB. Dated January 26th.

1,680. "Improvements in picking up electric current sent from a generating station by a railway car and returning it." R. C. SAYER. Dated January 26th. (Complete.)

1,692. "Improvements in electric telephony." C. ADAMS-RANDALL. Dated January 26th.

1,694. "Improvements in the treatment of carbon electrodes for electric arc lights." J. T. ROBINSON and J. H. FERGUSON. Dated January 26th. (Complete.)

1,704. "An electric alarm." B. J. B. MILLS. D. Pi l, n., France.) Dated January 26th.

1,711. "Improvements in or relating to electrical condenser batteries." E. VON SZVETICS. Dated January 26th.

1,781. "An improved connector for electric conductors." A. E. TANNER. Dated January 27th.

1,783. "Improvements in or relating to magneto-electric ignition devices." J. RIDLEY and J. W. ROEBUCK. Dated January 27th.

1,756. "Improvements in or connected with suspension devices for arc lamps and the like." O. WEHRMANN and H. BASTIANS. Dated January 27th.

ERRATA.—In last week's list Nos. 1,133 and 1,276 should be A. J. Boult, not "Bolt."

The following was omitted from our last issue:—

1,026. "An electric heater for heating water or other fluids." A. W. LAWTON. Dated January 16th. (Complete.)

ELECTRICAL PATENTS OF 1886 EXPIRING IN FEBRUARY, 1900.

WE are informed by W. P. Thompson & Co., that about 100 applications for electrical patents were filed in February, 1886. Of these some were never completed, and of those that were, only four have been maintained to run their full term, viz., 14 years, and being of considerable interest we give short abstracts of them below:—

1,538. "New or improved materials or compositions capable of being used for roads or footways, railway sleepers, pipes, underground receptacles for electric wires or cables and other purposes, either alone or in conjunction with iron or steel and apparatus or means employed in moulding such materials or compositions." J. W. Butler. Dated February 2nd, 1886. The composition is a mixture of bitumen, 15 lbs.; paraffin, 12 ozs.; sand or pulverised limestone, 8 lbs.; roughly pulped wood, 8 lbs.; Portland cement, 6 ozs.; and Taranaki sand, 8 ozs. The bitumen and paraffin are boiled together for about an hour before the other ingredients are added, and the latter previously heated, are gradually introduced while the liquid is at or near the boiling point. The order may be varied, but in all cases the Portland cement and Taranaki sand should be added last. In some cases the latter may be dispensed with, and in place of pulped wood tanyard waste or finely-sifted sawdust may be used. When used for making conduits for electric conductors, it is moulded into long blocks, with a number of perforations to receive the cables in a special mould. Two forms of this are made, one for round and the other for square blocks. In both forms the mould is in hinged segments, which are closed up as the material is tamped in. The perforations are produced by cores, encased in bituminous cloth or paper to facilitate their withdrawal, the cores being held in position by removable end plates. Metal skeleton rods may be inserted in the material if so desired. If any of the objects are required to be curved, they may be made in a straight mould, and then removed and bent while still warm. The composition is also applicable for pole insulators, for insulating belt electric cables, and generally as a substitute for vulcanite. 8 claims.

1,877. "Improvements in electric lamps." N. Tesla. Dated February 9th, 1886. Relates to arc lamps. The cores of a series magnet and a shunt magnet are furnished at the upper end with curved pole pieces and at the lower end with tapering pole pieces; the latter act upon a hollow armature attached to a tube provided at its upper end with internal projections which grip the carbon holder when the armature moves towards the pole piece of the series magnet; the clamp is carried by a lever attached to the frame of the lamp and movable about the point of attachment and by a link attached to an armature lever. The coil on the series magnet is in two parts; one part, normally in circuit, tends to polarise the core in the same way as the shunt magnet core; the second part, which is only included in the circuit when the lamp is cut out, tends to polarise the core in the opposite way. The carbons being in contact and the circuit completed, the armature is attracted by the main magnet and the holder clamped by means of the projections in the tube; the core of the shunt magnet is magnetised by the inductive action of the series magnet, and by the combined action of the two curved pole-pieces, the armature lever is turned and the carbons separated to strike the arc. When the arc becomes too long the strength of the shunt magnet core becomes sufficiently diminished to cause a movement of the lever in the opposite direction, and the clamp descends until the lever comes against a stop; any further increase in the length of the arc causes a movement of the armature and the carbon holder is released, the latter falling until the series magnet is sufficiently strong to cause the carbon holder to be again clamped, and, if necessary, slightly raised. When the arc reaches a predetermined length, the increase in strength of the shunt current is such as to draw the armature against the pole piece, contact between the two completing a short circuit including the second portion of the series magnet coils referred to, the latter confirming the polarity already existing, and thus ensuring that the short circuit remains completed, unless the carbons come into contact again, in which case the armature is attracted by the pole piece and the arc is struck as at first. 12 claims.

2,403. "Improvements for operating electric smelting furnaces." H. J. Haddan (E. H. Cowles and A. H. Cowles.) Dated February 15th, 1886. In the circuit comprising a smelting furnace and dynamo is inserted an amperemeter, or a resistance box is preferably immersed in water. 3 claims.

2,608. "Improvements in syphon recorders." W. P. Thompson. (C. Cuttries.) Dated February 23rd, 1886. Relates to siphon recorders. The poles of the line magnet are constructed with concentrically curved faces. One side of the coil is flattened out and moves between the poles, and the other side of the coil is carried through a slot in one pole. The siphon is supported by an adjustable thread and is attached to the coil by a thread. The method of supporting, actuating and causing a continuous flow of ink is by vibrating the siphon. A small piece of soft iron is fixed on the siphon and oscillated in the magnetic field between the poles of the magnet. A string timed to vibrate at the same rate as the siphon carries a contact maker, which intermittently makes and breaks the circuits of the magnets. 6 claims.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

Copies of any of these Specifications may be obtained of Messrs. W. P. THOMPSON and Co., 322, High Holborn, W.C., and at Liverpool, Manchester, and Birmingham, price, post free, 9d. (in stamps).

1897.

8,861. "Improvements in electric arc lamp mechanism." G. Percival. Dated April 8th, 1897. One carbon is carried by a float on glycerine, oil, water, or mixtures of these, and is connected electrically by a wire dipping in mercury, or a flexible conductor. The float is provided with a stem of such section at different parts as to maintain the carbon at the proper height as it burns away. The proper form of stem is found by providing first a uniform stem on which collars are placed as found necessary. The carbon passes through a guide to centre it near the arc. The carbon may be carried on the stem, or hung by rods from a cross-bar thereon. The float may be in a vessel floating within an outer one. The carbon float or inner vessel carries a tapered iron core above or

below a series or shunt solenoid, the action of which may be rendered uniform by causing the carbon holder to lift a cord or chain carrying small weights. The second carbon may be stationary or supported by cords on pulleys connected with the float. The arc may be struck by hand or otherwise. 5 claims.

9,008. "Improvements in or connected with dynamo-electric machines." V. A. Fynn. Dated April 8th, 1897. Armatures. A slotted drum armature is wound with separable overlapping spools or sections, each of which is laid in a pair of slots, the "step" of which depends upon the number of poles of the machine, and the total number of slots in the armature. One side of each section is laid in the bottom of its slot and the other side in the top, the end wires being bent outwards from one to the other. In the application of the invention to a four-pole machine, the armature is provided with 17 slots, in which case the step is from slot 1 to slot 5, and so on round the armature. The several sections are connected together by the conductors, which also form junctions with the commutator segments. 1 claim.

9,081. "Improvements in and relating to the distribution of electricity." H. F. Parshall. Dated April 9th, 1897. Relates to the distribution of electricity in systems such as have an overhead trolley and earth return. In order to keep the potential of the earth return within limits, a supplementary generator is arranged with the coils connected to distant points of the trolley and the armature, which is driven at a constant speed, connected to the earth returns. 1 claim.

9,127. "Improvements in electric meters." Evershed & Vignoles, Limited, and S. Evershed. Dated April 9th, 1897. Motor-meters are made with magnetically supported vertical spindles, and their commutators, when used, are made very small to render the frictional resistance unimportant. The counting gears are also independently driven, so that the meters only control their motion. The invention is partly applicable to alternating current induction meters, but the energy meter has a shunt armature supplied by a commutator within stationary field coils. Specification No. 2,642, A.D. 1882, is referred to. The soft iron or steel spindle carries a brake cylinder in the fields of symmetrically fixed permanent magnets. The inner poles of these are alike and connected by an iron yoke which carries a central iron pin within a bracket. A thin metal plate is clamped to this bracket by a ring. The ring surrounds the spindle to keep it in the magnetic field of the pin, which thus supports most of the weight of the spindle and keeps it central. The lower end of the spindle is a thin hard steel pin turning in a jewelled support. Several modifications are described. 8 claims.

9,135. "Electrical apparatus for automatically actuating ventilators, flue dampers, throttle valves, also for controlling and regulating sources of power." H. E. Yerbury. Dated April 10th, 1897. Relates principally to electro-magnet mechanism capable of turning an axis in opposite directions when certain fixed limits of temperature, speed, electric current, or the like are reached. It is applied to regulating and controlling ventilation, flue dampers, fire-extinguishing apparatus, the temperature of incubators, &c., the speed of electromotor tramcars and of marine engines, the feed-water of boilers, and the output of dynamos and electromotors. The electro-magnetic mechanism consists of two electro-magnets, either of which when energised by an electric current, pulls up a rod attached to its armature. A pawl on the end of each rod pulls round a toothed wheel in the direction required to exercise the necessary control on the ventilator or other apparatus. The electro-magnetic mechanism is described and shown combined with a thermostat, thermometer, &c. 5 claims.

9,184. "Improvements in heating by electricity." O. March. Dated April 10th, 1897. Ironing cylinders, flat irons, and other conducting bodies are heated by making them the secondary circuits of electric transformers with closed magnetic circuits. 2 claims.

9,276. "Improvements in primary batteries." W. Rowbotham. Dated April 12th, 1897. Relates to sealed batteries of the kind described in Specification No. 2,878, A.D. 1897, in which a mixture of sulphuric and nitric acids in water is fed through a series of cells to form the exciting fluid by mixing with water, and consists of providing the reservoir from which the acid is fed through the pipe into the first cell of the series, with a closed compartment into which the nitrous fumes generated in the battery pass through the pipe and accumulating here cause a constant pressure in the battery, as when a certain pressure is reached the gases become partly dissolved in the acid and partly pass through it causing an overflow into the main part of the cistern. The overflow from the last cell passes away through a syphon which permits the exhausted acid but not the gases to flow away. 1 claim.

9,425 "Improvements in electro-magnetic clutches or couplings." V. A. Fynn. Dated April 13th, 1897. In electro-magnetic clutches the exciting coil is wound in a fixed casing upon a boss through which passes the driving shaft. This has on its end a disc formed with projections; corresponding projections are formed on a disc secured to the driven shaft. 1 claim.

9,457. "Improvements in electrical transformers." A. F. Berry. Dated April 13th, 1897. The core is constructed of a number of flat plates which are interlocked so as to leave a space for the coils. These plates are formed in radial groups between which are fitted groups of smaller plates. In building a transformer, the plates are held on a "former" between two grooved end plates secured by a bolt. The primary and secondary coils are then wound, being separated by suitable insulating material. The cores are then completed by placing the plates in position, and separating the groups by the wooden or like blocks, the whole being tightly bound with wire. The "former" and end-plates are then removed, leaving large ventilating spaces, and the transformer fitted in a casing having suitable terminals and connections. To facilitate dissipation of heat, copper tubes coated with lampblack are, in modifications, arranged around or between the sections and a current of water or the like caused to flow through. End chambers may be formed in the casing with which the tubes are connected. The invention is stated to be an improvement upon the transformer described in Specification No. 2,801, A.D. 1897. 2 claims.

9,537. "Improvements in commutator trueing devices." P. B. Bosworth. Dated April 14th, 1897. Relates to a device for trueing or turning down commutators by hand power without removal from the shaft, which device is applicable also to other purposes, such as turning or cutting off shafting. The tool holder is fitted into a screw threaded sleeve carried by the driving head which is mounted adjustably on a hand crank supported by a two part collar rotatable on the shaft. As the driving wheel is revolved round the shaft a horizontal feed is given to the tool holder by means of a screw threaded sleeve, to which a rotary movement is imparted by a star wheel engaging with a feed pin supported by a second two-part collar fixed on the shaft. 4 claims.

9,563. "Improvements in or relating to plates for secondary batteries or accumulators." H. T. Cheswright. Dated April 14th, 1897. The plates consist of a number of lead strips or ribbons which may be plain, corrugated, or embossed, and the upper ends of which are burnt into a conducting bar, while their lower ends are left free. The ribbons are arranged in groups with spaces between them, and are surrounded by a framework serving as a separator. 1 claim.

9,586. "Improvements in current collecting apparatus for electric tramways." C. W. G. Little and H. J. Ireland. Dated April 15th, 1897. Collectors for use with overhead conductors. The springs which press the pole up to its work are contained within the standard. The pole socket is hinged on an arm on the swivelling head which runs on ball bearings on the standard. Two or more helical springs attached to the head carry a plunger with adjustable head which bears under rollers attached to the pole. The conductor is led down through the plunger. Stops prevent complete rotation of the head, but in a modified form this rotation is allowed by a swivelling joint in the conductor. This consists of an insulated extension of the lower part of the plunger working in an insulated ring inside the standard, these two parts being connected to the two ends of the conductor. 3 claims.

9,707. "Improvements in alternating current motors." O. T. Blathy and K. Kando. Dated April 15th, 1897. Relates to alternating current motors. Consists in making the grooves of the stator or of the rotor, or of both the stator and the rotor oblique to the axial line or the generatrices of the cylindrical surface, so as to avoid dead points. 1 claim.

9,708. "Improved method of and means for preventing disturbances in telephone circuits by alternating current installations." O. T. Blathy and K. Kando. Dated April 15th, 1897. Induction due to alternating currents is prevented by employing in the alternating current installation motors adapted for alternations of a frequency of about 20 per second. The motor and stator are provided with grooves oblique to the axis and to one another. 2 claims.

9,803. "A voltaic battery having its depolarisation effected by heat." H. E. D. R. D. Lavison. Dated April 17th, 1897. The positive electrodes are mounted on a shaft, so that they can be slowly rotated, and while rotating, the part not immersed in the electrolyte is depolarised by heat, either by hot air caused to circulate through the chamber in which the electrodes are contained, or by a flame applied directly to each of them. 1 claim.

9,913. "A manufacture of electrodes for electric accumulators." E. Marckwald. Dated April 20th, 1897. The active material, or material to be rendered active, consists of basic lead salts of butyric or lactic acids or of a mixture of the same. They are formed by adding to a 10 to 12 per cent. solution of the acid finely-powdered lead oxide to a weight of from five to seven times that of the acid. 1 claim.

9,914. "A manufacture of electrodes for electric accumulators." E. Marckwald. Dated April 20th, 1897. The material to be rendered active consists of a mixture of lead oxide or red lead with milk. 1 claim.

9,967. "Improvements in telegraphic transmitters." E. Porter. Dated April 21st, 1897. Transmitters for Morse signalling are arranged with a number of keys each provided with a notched plate corresponding to the dots and dashes of the various signals. The key rod is held up by a spring, and carrying two plates, between which the notched signal plate is arranged. When depressed, the notched plate operates the slide plate; this is held forward by a spring carrying at its free end an adjustable contact piece capable of making contact with the bar when the slide enters the notches in the plate. A spring-supported locking plate, which slides through the frame and the plate, but is moved up and down by the plates. The line, &c., battery connections are through. 3 claims.

9,968. "Improvements in or relating to the electric control of gas." J. H. Kerridge. Dated April 21st, 1897. Relates to lighting gas by electricity. In order to keep the igniting wire from being heated except at the instant of ignition, one or preferably two bye-pass burners, supplied from a common valve, are employed, the igniting wire being located in one of the bye-pass burners. The main valve and the bye-pass valve are respectively pivoted to levers which are themselves pivoted to a central rod. A third lever provided with a notched extension is pivoted to a lever which serves as an armature. When the current is sent through the electro-magnet and igniting wire, one end of this lever and the attached lever are lifted, whereupon the notch engages with a projection, the other end of the pivoted armature lever opens the bye-pass valve and the pilot jet is lit from the igniting wire. If the circuit through the electro-magnet be now broken, the armature lever drops, and by means of the notch carries with it the corresponding end of the lever and opens the main valve, the movement of the armature lever closing the bye-pass valve after the ignition of the main burner. The light is extinguished by energising the magnet, which, attracting the free end of the armature lever, releases the notch from the projection. The weighted end then operates a lever and closes the main valve. 8 claims.

12,327. "A new or improved device for use im connection with storage batteries." G. Walter. Dated May 18th, 1897. Consists of appliances for removing from the battery the portions of the active material, &c., which have fallen off the plates. The appliance for removing large lumps has a spatula-shaped end; another has its end divided into compartments, and serves to collect the finely separated particles, and another serves for removing material from beneath the plates. 2 claims.

12,435. "Improvements in electric conducting cords, and means for connecting them to walls or other supports." M. K. Percl and F. Schacherer. Dated May 19th, 1897. Distance pieces of insulated material are woven into electric conductors. These pieces are formed with a central groove in which the conductors lie between the head and distance portion. The latter part may be an enlarged washer or of rectangular shape, and may be made separate from the shank and head, in which case the two parts are secured together after being fixed in the cable. 4 claims.

13,099. "Improvements in silvered glass reflectors for incandescent electric lamps and in the method of manufacturing such reflectors." E. Edwards. (H. Munzel.) Dated May 27th, 1897. Reflectors for incandescent electric lamps are formed of silvered glass. The glass after being blown to the shape shown, is re-heated and pressed to the form shown, and the space between the double walls is silvered. An opening to fit the lampholder exactly is subsequently cut out by means of emery, and the upper part of the blown glass is removed. 3 claims.

13,100. "Improvements in or connected with primary or galvanic electric batteries." C. N. Gauzentes. Dated May 27th, 1897. Relates to a portable sealed battery particularly adapted for use with cycle, miners' and like electric lamps. Each cell consists of a lead tube closed at top and bottom by wooden plates, and having carbon electrodes fastened against the lead walls by lead strips, the ends of which are burnt on to the cell walls. In the plate is a central orifice which serves for the introduction and withdrawal of the electrolyte and the zinc electrode, and the battery is rendered liquid-tight by means of the rubber disc, the orifice of which is smaller than that of the plate, and by a rubber ring which is clamped between the top of a flanged tubular piece and a disc on the upper part of the zinc electrode by means of the screw and bridge piece or cap. The zincs are made short, so that the action of the battery may be started or stopped by turning it on the pivot through a half revolution, or the current may be stopped by withdrawing the zincs from the battery. The cells may be contained in a case, insulating material being packed between it and the cells. 3 claims.

13,117. "Improvements in electric meters and motors for alternating, pulsating, or intermittent current." G. F. Packard. Dated May 27th, 1897. (Date claimed under Patents, &c., Act, 1883, Sec. 103, October 26th, 1896, being date of application in United States.) Relates to motors applicable mainly as meters for alternating or intermittent currents. A spindle connected to a counter carries an aluminium or other conducting armature having radial vanes, situated near laminated iron cores surrounded by coils conveying the current, so that the vanes are repelled and the armature caused to rotate. Its rotation is retarded by the air. In a form shown the vanes are vertical and slotted to partly admit two laminated cores, but they may be unslotted and inclined to the direction of motion, so that the magnets tend to lift the armature to facilitate starting; four cores may be used and large coils, each of which surrounds the armature and a pair of the cores. 5 claims.

13,212. "Improvements in, or additions to, the covers or casings of switches, cut-outs, ceiling roses, and other electrical fittings." T. Taylor. Dated May 28th, 1897. The cases or covers of electric fittings are formed with a lining of vitreous material, porcelain or other non-conducting material and a metallic outer shell. One form is shown suitable for a tumbler switch. The metal shell is pierced, turned down, and formed with a screw thread. It is secured to the lining by means of a lip or beading spun or otherwise formed. In other forms the edge of the screwed part is bent under the lining, or the edge is bent under or a rib may be forced into a groove in the lining. 4 claims.

13,213. "Improvements in the tubes or cases of electric fuses." H. T. Taylor. Dated May 28th, 1897. In order to increase the internal area of the tubes or cases containing fuse wires, they are formed with grooves, corrugations, ribs, or the like in or along the bore. 2 claims.

13,221. "Improvements in electrical cut-outs." C. M. Dorman and R. A. Smith. Dated May 28th, 1897. Cut-outs fitted with fuse wires are enclosed in a casing, and openings or vents are formed in the casing in close proximity to the wire, so that when it fuses the rush of gas tends to prevent the formation of an arc or to blow it out if formed. This system may be applied to cut-outs having baffle-plates or bridges, and to single and double-pole cut-outs. 1 claim.

13,414. "Improvements in or relating to safety fuses for electric circuits." C. J. Hall and H. J. Fuller. Dated May 31st, 1897. Safety fuses are sheathed with an incombustible material to prevent danger of fire. Asbestos or the like may be plaited or otherwise wrapped round the wire, or may be formed into a casing to receive the wire core. 1 claim.